NASA SP-7037 (293)
July 1993

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

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National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1993

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INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 476 reports, journal articles, and other documents recently announced in the NASA STI Database.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)	N93-24659 — N93-26604
International Aerospace Abstracts (IAA) (A-10000 Series)	A93-33481 — A93-35700

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the publication consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals.

Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1993 will be published in early 1994.

Information on availability of documents listed, addresses of organizations, and CASI price schedules are located at the back of this issue.

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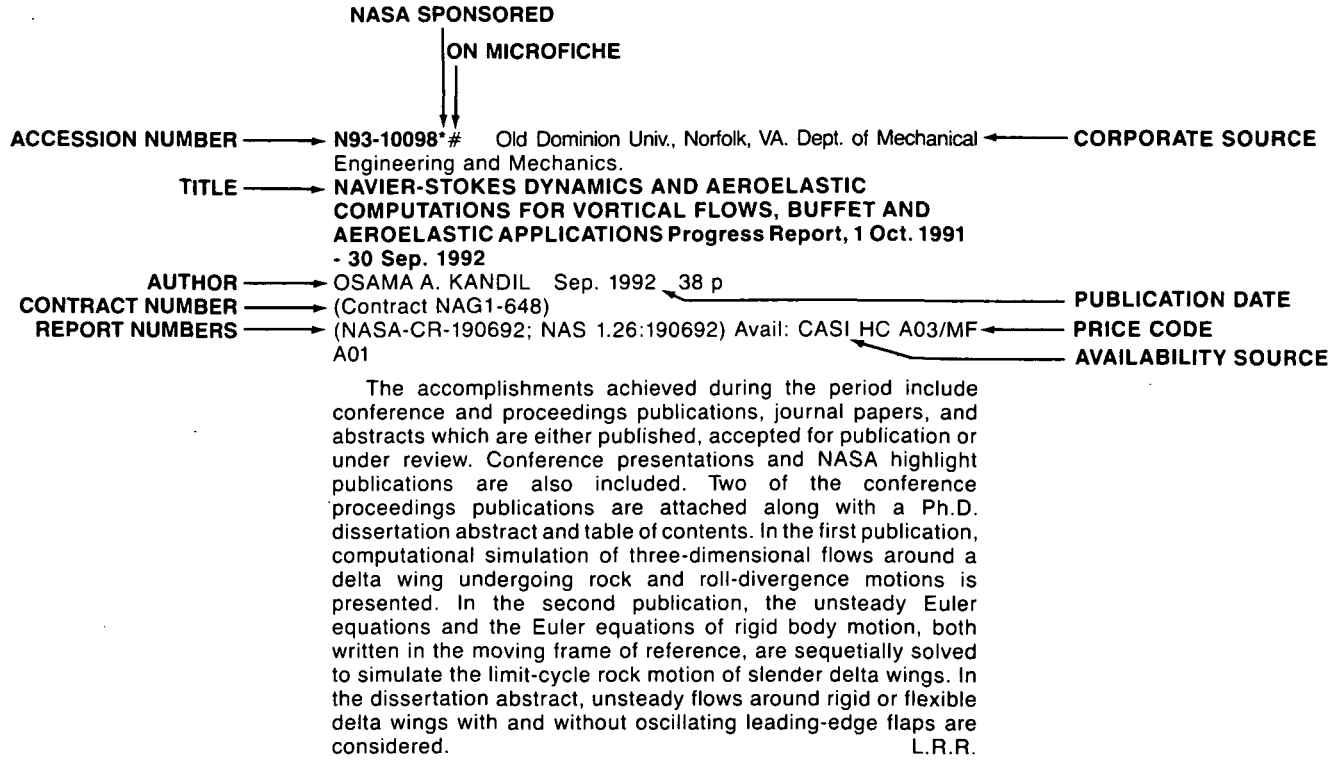
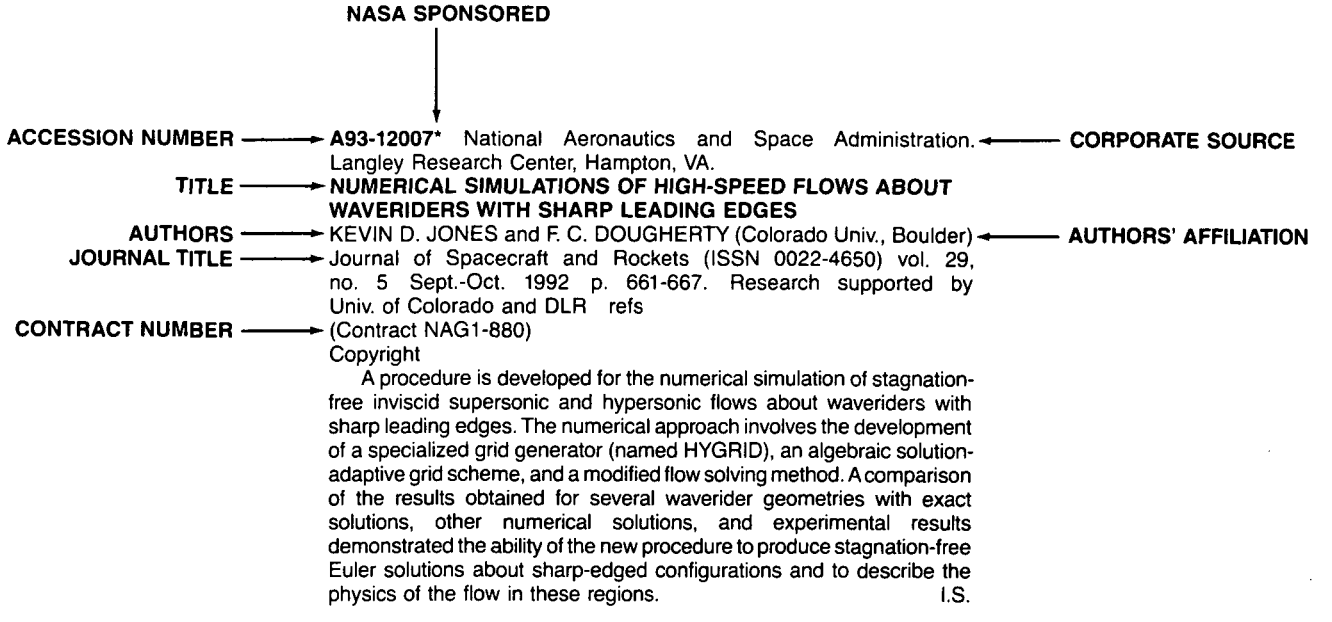
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 293)

July 1993

01

AERONAUTICS (GENERAL)

A93-34587
AN UNMANNED AIRCRAFT FOR DROPWINDSONDE DEPLOYMENT AND HURRICANE RECONNAISSANCE
JOHN S. LANGFORD (Aurora Flight Sciences, Manassas, VA) and KERRY A. EMANUEL (MIT, Cambridge, MA) American Meteorological Society, Bulletin (ISSN 0003-0007) vol. 74, no. 3 March 1993 p. 367-375. refs
Copyright

The prototype of a remotely piloted aircraft designed for research and operational reconnaissance of tropical cyclones has been developed and successfully test flown. Using modern aerodynamic and materials technology, the operational aircraft will by 1994 be capable of sustained operations at altitudes up to 20 km and of deploying large numbers of frangible dropwindsondes. We discuss the potential of such vehicles for making significant improvements of hurricane forecasts and for enhancing the database used in operational weather forecasts, atmospheric research, and climate monitoring. Author

A93-34947
TAKING TO THE SKIES UNDER HYDROGEN POWER - DEUTSCHE AEROSPACE AIRBUS STUDIES THE USE OF ALTERNATIVE FUELS FOR CIVIL AVIATION
New-Tech News (ISSN 0935-2694) no. 1 1993 p. 17-19.
Copyright

Two cryogenic fuels, LH2 and LCH4, are under investigation by a European manufacturer of commercial aircraft in the interest of lowering atmospheric pollutants and reducing dependence on eventually depletable stocks of hydrocarbon fossil fuels. Attention is presently given to LH2, which is less volumetrically efficient than LCH4 but yields much greater heatsink potential for propulsion system cooling. The infrastructural task, however, is daunting; while only 20 tons/day of LH2 are currently produced in Europe, its use as a basis for civil aviation would require the availability of 6000 tons/day. AIAA

A93-35184#
MIL-PRIME SPECIFICATION FOR PARACHUTES
ANDREW S. KIDIDIS (USAF, Aeronautical Systems Center, Wright-Patterson AFB, OH) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 285-288. refs
(AIAA PAPER 93-1247)

Attention is given to the Mil-Prime, in particular MIL-P-87141, specifications geared toward the acquisition of parachute and decelerator systems. Mil-Prime definition, characteristics, environmental conditions, and special provisions are discussed. MIL-P-87141 is demonstrated to be a straightforward document that provides an excellent baseline for the acquisition development of parachutes as either a subsystem or a primary system. AIAA

A93-35677
MODELING AND OPTIMIZATION OF AIRCRAFT ASSEMBLY [MODELIROVANIE I OPTIMIZATSIIA SBORKI LETATEL'NYKH APPARATOV]
ANATOLII I. BABUSHKIN Moscow Izdatel'stvo Mashinostroenie 1990 240 p. In Russian.
(ISBN 5-217-00808-3) Copyright

The theoretical fundamentals of the computerized generation of technical documentation for the line assembly of aircraft are presented, and algorithms for implementing the process on a computer are described. In particular, attention is given to the problem of aircraft assembly optimization in the case of a limited number of available types of resources. Several CAD/CAM systems for the line assembly of aircraft are described. AIAA

N93-24760*# Purdue Univ., West Lafayette, IN.
THE WINCOF-I CODE: DETAILED DESCRIPTION
S. N. B. MURTHY and A. MULLICAN Apr. 1993 119 p Sponsored in part by US DOT, Atlantic City International Airport, NJ
(Contract NAG3-481; RTOP 505-62-21; DTFA03-83-A-00328)
(NASA-CR-190779; E-7719; NAS 1.26:190779;
DOT/FAA/CT-TN92-10) Avail: CASI HC A06/MF A02

The performance of an axial-flow fan-compressor unit is basically unsteady when there is ingestion of water along with the gas phase. The gas phase is a mixture of air and water vapor in the case of a bypass fan engine that provides thrust power to an aircraft. The liquid water may be in the form of droplets and film at entry to the fan. The unsteadiness is then associated with the relative motion between the gas phase and water, at entry and within the machine, while the water undergoes impact on material surfaces, centrifuging, heat and mass transfer processes, and reingestion in blade wakes, following peal off from blade surfaces. The unsteadiness may be caused by changes in atmospheric conditions and at entry into and exit from rain storms while the aircraft is in flight. In a multi-stage machine, with an uneven distribution of blade tip clearance, the combined effect of various processes in the presence of steady or time-dependent ingestion is such as to make the performance of a fan and a compressor unit time-dependent from the start of ingestion up to a short time following termination of ingestion. The original WINCOF code was developed without accounting for the relative motion between gas and liquid phases in the ingested fluid. A modification of the WINCOF code was developed and named WINCOF-1. The WINCOF-1 code can provide the transient performance of a fan-compressor unit under a variety of input conditions.
Author (revised)

N93-25134*# Purdue Univ., West Lafayette, IN. School of Mechanical Engineering.
TRANSIENT PERFORMANCE OF FAN ENGINE WITH WATER INGESTION Interim Report
S. N. B. MURTHY (Purdue Univ., West Lafayette, IN.) and A. MULLICAN (Purdue Univ., West Lafayette, IN.) Apr. 1993 254 p
(Contract NAG3-481; DTFA03-83-A-00328; RTOP 505-62-21)
(NASA-CR-190778; E-7709; NAS 1.26:190778;
DOT/FAA/CT-TN92/11) Avail: CASI HC A12/MF A03

In a continuing investigation on developing and applying codes for prediction of performance of a turbine jet engine and its

components with water ingestion during flight operation, including power settings, and flight altitudes and speed changes, an attempt was made to establish the effects of water ingestion through simulation of a generic high bypass ratio engine with a generic control. In view of the large effects arising in the air compression system and the prediffuser-combustor unit during water ingestion, attention was focused on those effects and the resulting changes in engine performance. Under all conditions of operation, whether ingestion is steady or not, it became evident that water ingestion causes a fan-compressor unit to operate in a time-dependent fashion with periodic features, particularly with respect to the state of water in the span and the film in the casing clearance space, at the exit of the machine. On the other hand, the aerodynamic performance of the unit may be considered as quasi-steady once the distribution of water has attained an equilibrium state with respect to its distribution and motion. For purposes of engine simulation, the performance maps for the generic fan-compressor unit were generated based on the attainment of a quasi-steady state (meaning steady except for long-period variations in performance) during ingestion and operation over a wide enough range of rotational speeds. Author (revised)

N93-26136*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
BIBLIOGRAPHY ON PROPULSION AIRFRAME INTEGRATION TECHNOLOGIES FOR HIGH-SPEED CIVIL TRANSPORT APPLICATIONS, 1980-1991
DAVID J. ANDERSON and MASASHI MIZUKAMI Mar. 1993 343 p
(Contract RTOP 537-02-23)
(NASA-TM-105602; E-6938; NAS 1.15:105602) Avail: CASI HC A15/MF A03

NASA has initiated the High Speed Research (HSR) program with the goal to develop technologies for a new generation, economically viable, environmentally acceptable, supersonic transport (SST) called the High Speed Civil Transport (HSCT). A significant part of this effort is expected to be in multidisciplinary systems integration, such as in propulsion airframe integration (PAI). In order to assimilate the knowledge database on PAI for SST type aircraft, a bibliography on this subject was compiled. The bibliography with over 1200 entries, full abstracts, and indexes. Related topics are also covered, such as the following: engine inlets, engine cycles, nozzles, existing supersonic cruise aircraft, noise issues, computational fluid dynamics, aerodynamics, and external interference. All identified documents from 1980 through early 1991 are included; this covers the latter part of the NASA Supersonic Cruise Research (SCR) program and the beginnings of the HSR program. In addition, some pre-1980 documents of significant merit or reference value are also included. The references were retrieved via a computerized literature search using the NASA RECON database system. Author (revised)

N93-26168# Naval Postgraduate School, Monterey, CA.
SPECIAL TOOLING DISPOSITION FOR AIRCRAFT ENTERING POST PRODUCTION SUPPORT M.S. Thesis
LEE G. EBERT Dec. 1992 53 p
(AD-A261614) Avail: CASI HC A04/MF A01

This thesis identifies and analyzes an important element of Department of Defense (DoD) Post Production Support (PPS) for plan execution: the disposition of special tooling used to support future manufacturing of aircraft components. As a first step, PPS and its goals are described. Next, the DoD policies for special tooling management are described. Finally, the effects of special tooling disposition are analyzed and a decision process for disposition is presented which incorporates these effects. Further research is recommended to measure the effects tooling disposition decisions have on lead times and manufacturing costs when considering conventional, Rapid Acquisition of Manufactured Parts (RAMP) or Flexible Manufacturing System (FMS) manufacturing methods. DTIC

N93-26238# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
AN ANALYSIS OF THE RELIABILITY AND MAINTAINABILITY OF THE JIAN 6 AND JIAN 7 AIRCRAFT AND WAYS TO IMPROVE THEM
LI ZISHANG and MAO JINGLI 27 Jan. 1993 14 p Transl. into ENGLISH from unidentified Chinese document p 2-6
(Contract F33657-88-D-2188)
(AD-A261060; FASTC-ID(RS)T-0628-92) Avail: CASI HC A03/MF A01

Reliability and maintainability are major standards for measuring the superiority of an aircraft. They are major factors in the combat capabilities of the Air Force. Striving to improve and enhance the reliability and maintainability of the aircraft with which the Naval Air Forces are currently primarily equipped, the Jian 6 and the Jian 7, are urgent tasks of Air Force maintenance operations. This article presents a thorough and wide ranging survey of aircraft manufacturing facilities and Naval Air Force Unit plants, and by combining, analyzing and studying this survey, it presents methods and means of improving the reliability and maintainability of the Jian 6 and Jian 7 aircraft. DTIC

N93-26325# Joint Publications Research Service, Washington, DC.
JPRS REPORT: CENTRAL EURASIA. AVIATION AND COSMONAUTICS, NO. 9, SEPTEMBER 1992
26 Apr. 1993 33 p
(JPRS-UAC-93-003) Avail: CASI HC A03/MF A01

Translated articles cover the following topics: independent body to protect professional interests of pilots sought; future use of artificial intelligence on fighters considered; theoretical refinement to Zhukovskiy aerodynamic theorem proposed; comprehensive approach to seeking causes of air accidents urged; consideration of psychological factors in training and performance; new edition of aviation engineering support manual; a description of the plight of CIS strategic fliers outside Russia; more history of failed N1-L3 Lunar Launch-Vehicle Project; a plan to counter ozone layer destruction with space-based mirrors; Soviet air advisor recalls Vietnam tactics against B-52 Bombers; and comparison of ZMS2 and KC-135A tanker aircraft data. CASI

N93-26422*# National Aeronautics and Space Administration, Washington, DC.
AERONAUTICS IN NACA AND NASA
1991 81 p Original contains color illustrations
(NASA-NP-156; NAS 1.83:156) Avail: CASI HC A05/MF A01; 13 functional color pages

Initiated in 1915, the National Advisory Committee for Aeronautics/National Aeronautics and Space Administration (NACA/NASA) aeronautical programs have been the keystone of a sustained U.S. Government, industry, and university research effort which has been a primary factor in the development of our remarkable air transportation systems, the country's largest positive trade balance component, and the world's finest military Air Force. This overview summarizes the flow of events, and the major trends, that have led from the NACA origins to the present NASA Aeronautics program, and indicates some important directions for the years ahead. Derived from text

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A93-33703
KARMAN VORTEX STREET-AIRFOIL INTERACTION
KEQIN ZHU (Univ. of Science and Technology of China, Hefei)

and F. OBERMEIER (Max-Planck-Inst. for Fluid Dynamics, Goettingen, Germany) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 4 Dec. 1992 p. 422-434. refs

Based on the discrete vortex method, a conformal mapping technique is used to solve Karman vortex street-airfoil interaction. The characteristics of the interaction as an acoustic source of the dipole type are investigated and the evolution of the wake is simulated. Calculated results show that the sound power absorbed by the wake may be positive or negative during the time process. It is also found that the strength of the acoustic dipole in the far field and airfoil lift appears to fluctuate periodically. This kind of periodic fluctuation is one of the main reasons for the aerodynamic noise and oscillation of airfoils. Author (revised)

A93-33706
GROUND EFFECT ON THE TAKE-OFF CHARACTERISTICS OF SEA-BASED AIRCRAFT

NAIPING ZHANG, GUOFENG LIN, and ZHIDAI HE (Northwestern Polytechnic Univ., Xian, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 4 Dec. 1992 p. 451-457. In Chinese. refs

To meet the strict demands for sea-based aircraft during takeoff and landing is the most important flight dynamic problem to be solved. One of the main differences between takeoff from the ground and from the deck is that the ground effect decreases gradually after liftoff from the ground, while it decreases suddenly in case of liftoff from the deck. The ground effect has considerably influences drag, downwash field behind the wing, and especially lift. The sudden loss of lift may cause so called 'sink' for sea-based aircraft at the instant of liftoff from the deck, which may cause safety problem for aircraft. A synthetic method is presented here to estimate ground effects on aerodynamic forces and moments of a complete aircraft. The change of take-off characteristics, especially the sinkage, caused by sudden loss of ground effect has been studied and a relevant numerical method has been developed. Author (revised)

A93-33709
FINITE-VOLUME-TVD SCHEME FOR 3-D EULER TRANSONIC FLOW COMPUTATIONS IN ROTATING CURVILINEAR COORDINATES

BAOGUO WANG and YINGUI BIAN (Chinese Academy of Sciences, Inst. of Mechanics, Beijing, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 4 Dec. 1992 p. 472-481. In Chinese. refs

An efficient algorithm is presented that exploits the properties of both TVD schemes developed by Harten (1984) and Runge-Kutta ones developed by Jameson. The 1D Harten scheme is extended to 3D nonlinear hyperbolic conservation laws. The new algorithm has been used to compute 3D Euler transonic or supersonic flows in rotating reference frames. The 3D transonic flow field is selected within an axial flow single-stage compressor rotor tested by DFVLR. Comparisons between the computed flow and experimental data show good agreement and show that the algorithm can capture the shock in 1-3 grid points. The algorithm is quite robust and can generate good shock resolution. AIAA

A93-33713
ON THE FAVORABLE INTERFERENCE IN THE SUPERSONIC FLOW

ZHICHENG HUANG (Beijing Inst. of System Engineering, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 4 Dec. 1992 p. 499-505. In Chinese. refs

Two integrated relations of the singularity distribution are derived with the integrated property of 3D supersonic flow. The first formula is the integrated relation for source distribution. The special case of the first formula is the result obtained by Ferri (1957) on favorable interference in the supersonic flow. The second formula is the integrated relation for elementary vortex distribution. The problem of interference of the singularity distribution in space is studied with these formula. The interference characteristics for the body under the wing, the wing under the body, one body under the wing, and one body over the wing are analyzed. The phenomena of favorable interference in the supersonic flow are analyzed. Several possible types of favorable interference are pointed out. Author (revised)

A93-33715
NUMERICAL SOLUTION OF NON-ISENTROPIC TRANSONIC CASCADE FLOW BY TIME-MARCHING METHOD

XIAOMIN JIANG and ZHIGUANG LING (Shanghai Univ. of Engineering Science, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 4 Dec. 1992 p. 513-518. In Chinese. refs

A set of equations is derived based on Viviand's formulation for solving nonisentropic inviscid pseudounsteady cascade flows. Numerical solution is obtained by employing the improved time-marching scheme. The calculated results show good agreement with the accurate solution and experimental results. The reduction of calculation time is obvious in comparison with the current time-marching solution of Euler equation. The suggested method is appropriate for the engineering applications. Author (revised)

A93-33716
ANALYSIS OF SLENDER BODIES OF REVOLUTION WITH AN ANGLE OF ATTACK IN EXTREME GROUND EFFECT

QIANXI WANG (Univ. of Science and Technology of China, Hefei) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 157-164. In Chinese. refs

A slender body of revolution with an angle of attack is analyzed for motion with constant forward velocity, in very close proximity to a plane wall, by using the method of matched asymptotic expansions. The analytic asymptotic solution of the induced flow is given. The attractive force and pitching moment acting on the body are obtained in terms of the integrals over the body length. The kinematic and dynamic characters of the extreme ground effect on the slender body are analyzed. Author

A93-33717
ADAPTIVE WALL WIND TUNNEL WITH TWO MEASURED INTERFACES - THEORY AND EXPERIMENT

C. F. LO (Tennessee Univ., Tullahoma), SHUJIE WANG (Harbin Aerodynamics Inst., China), and N. ULBRICH (Tennessee Univ., Tullahoma) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 165-175. refs

An adaptive wall wind tunnel with two measured interfaces has been investigated. A two-dimensional NACA 0012 airfoil model at a supercritical Mach number was tested. Static pressure measurements near tunnel walls on two interfaces were taken. Based on these measurements an iterative procedure is described to obtain interference free flow in an adaptive wall wind tunnel. The functional relationships of static pressures on two measured interfaces for the exterior region are presented. The convergence of the selected iterative procedure is described. The one-step convergence formulas are obtained and validated by the simulation of a numerical wind tunnel. The results have indicated that the selected procedure is feasible to speed up the flow convergence to the unconfined condition in applying the one-step convergence formulas. Author

A93-33718
PRESSURE FLUCTUATIONS ON THE SURFACE OF TWO CIRCULAR CYLINDERS IN TANDEM ARRANGEMENTS AT HIGH REYNOLDS NUMBERS

ZHIFU GU, TIANFENG SUN (Beijing Univ., China), DEXIN HE, and LIANGLIANG ZHANG (China Aerodynamics Research and Development Center, Mianyang) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 176-184. In Chinese. refs

Results are presented of a study of the fluctuating pressure distributions on the surface of a circular cylinder and of two identical circular cylinders arranged in tandem, in a high-Reynolds-number turbulent flow (at Re = 3.25 x 10 exp 5 and Re = 6.5 x 10 exp 5, respectively). It was found that, at these high subcritical and low supercritical Reynolds numbers, the pressure distributions on

the single circular cylinder had different features from those obtained at lower subcritical and higher supercritical Re values. At 3.25 x 10 exp 5, there was evidence of regular vortex shedding from the surface of the cylinder. In contrast, no regular shear layer separated from the surface of cylinder was observed at Re = 6.5 x 10 exp 5. AIAA

A93-33719
NUMERICAL SIMULATION OF PASSIVE CONTROL OF SHOCK-BOUNDARY LAYER INTERACTION FOR TRANSONIC AIRFOIL

YIBIN WANG (Chinese Academy of Sciences, Inst. of Mechanics, Beijing, China), BINGYONG CHEN, and ZIQIANG ZHU (Beijing Univ. of Aeronautics and Astronautics, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 185-194. In Chinese. refs

The effect of reducing total drag of transonic airfoils is specially studied. An interactive boundary layer (IBL) algorithm is employed in order to observe the influences of porous surface on strength and structure of shocks as well as the effects on controlling the boundary layer. The numerical results of NACA0012 airfoil indicate that the nature blowing-suction porous model can appreciably reduce strength of shock and change its structure, but it can also increase the losses of viscosity. The total drag is increased at lower Mach numbers and reduced at higher Mach numbers. This tendency accords with experimental results. Author

A93-33722
EULER SOLUTION FOR WING-BODY COMBINATION AT SUPERSONIC SPEEDS

WANCHUN CHEN, ZHENSHEN YANG (Beijing Univ. of Aeronautics and Astronautics, China), and CHUQUN JI (Beijing Inst. of Aeronautics, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 210-217. In Chinese. refs

Space marching methods are used here to solve the Euler equations of a wing-body configuration at supersonic speeds by MacCormack's scheme. The thin-fin approximation is employed to generate the computational grid. Kentzer's approach is used to treat boundaries. By modifying the crossflow velocity profiles for the consideration of viscous effects, the leeside surface pressure distributions are improved considerably, flow separation is formed in the leeside region in the meantime, and computational interruption problems caused by numerical oscillations are solved. Author

A93-33723
THE INFLUENCE OF WALL FRICTION ON SIDEWALL INTERFERENCE

KEMING CHENG and YIYI HUANG (Nanjing Aeronautical Inst., China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 218-224. In Chinese. refs

This paper studies the effect of wall friction on wind-tunnel-sidewall interference. The paper analyzes the boundary layer on a sidewall by means of the Karman-Pohlhausen method. It is indicated that the influence level of the friction on the sidewall interference depends on Pohlhausen's parameter B. The less the parameter B is, the larger the influence is. Barnwell's result only corresponds to the situation with a separated boundary layer, and in fact the attached boundary layer was dealt with. The paper establishes a new formulation for correction of sidewall interference, and considers a number of effects on B. It is preliminarily suggested that the parameter B be taken, on the average, as 3-4. Finally, the selection of the correction parameter is discussed. Author

A93-33725
AN EXPERIMENTAL STUDY ON LOCATION OF TRANSITIONAL SEPARATION BUBBLE ON A LOW REYNOLDS NUMBERS AIRFOIL

TIECHENG WANG (Nanjing Aeronautical Inst., China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 235-238. In Chinese. refs

An experimental study was undertaken to locate the transitional separation bubble which often occurs on an airfoil operating at low Reynolds numbers. The surface hot film gages on the surface of airfoil gave the oscillograms of a voltage and the RMS value of a fluctuating voltage. The points of laminar boundary layer separation and turbulent boundary layer reattachment were obtained from these results. Then the transitional separation bubble was located. Author (revised)

A93-33727
THE NUMERICAL CALCULATION AND APPLICATION OF COMPRESSIBLE BOUNDARY LAYERS ON LAMINAR-FLOW-CONTROL AND NATURAL-LAMINAR-FLOW WINGS

DENGBIN TANG (Nanjing Aeronautical Inst., China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 244-249. In Chinese. refs

In this paper compressible boundary layers on swept laminar flow wings are investigated computationally. A new form of similarity transformation, into which no singularity will be introduced, is adopted. Partial differential equations are derived by using this new transformation. Examples of laminar flow control (LFC) and natural laminar flow (NLF) wings are calculated and useful results are obtained. Author (revised)

A93-33729
CALCULATION OF OPTICAL AND ELECTRIC CHARACTERISTICS FROM HYPERSONIC BLUNT-BODY WAKES

XUEHUA ZHOU (Chinese Academy of Sciences, Inst. of Mechanics, Beijing, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 255-260. In Chinese. refs

A simplified flow field model and simple air chemical model for the chemical nonequilibrium wakes of hypersonic nonablating blunt bodies are presented. The models are applied to calculate the integrated electron density and NO2 chemiluminescence in the wakes. Numerical results of NO2 chemiluminescent emission over the wavelength region 0.4-1.2 and over any wavelength interval of interest are obtained. The calculated results are compared to the wake measurements in the ballistic region. The agreement between them is good. Author (revised)

A93-33730
SOLUTION OF EULER EQUATIONS FOR COMPLEX FOREBODY-INLET COMBINATIONS

XIAOQING ZHENG, HUILI SHEN, MINGGANG JI, and ZONGWEN XING (Northwestern Polytechnical Univ., Xian, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 261-265. In Chinese. refs

A new methodology was developed for simulating the aircraft forebody-inlet combination flowfields. The solution algorithm is based on the Jameson-type (Jameson et al., 1981) finite volume, Runge-Kutta time stepping scheme. The algorithm was successfully applied to the calculation of integrated flowfields about a missile forebody-inlet configuration and a supersonic fighter inlet. AIAA

A93-33733
THE STAGNATION LINE SOLUTION OF THE EQUILIBRIUM FLOW WITH RADIATION AND MASS INJECTION

KUI BAI, ZHANGHUA QU, and JIANWEI SHEN (National Univ. of Defense Technology, Changsha, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 277-282. In Chinese. refs

The chemical equilibrium viscous shock-layer equations at the stagnation line are solved numerically in this paper. The effects of radiation and mass injection are considered. Detailed line and continuum radiation models are included. The flowfield is devided into two zone as the surface mass is injected, one from the surface to v = 0 which contains the injected species and the other from v = 0 to the shock in which there are no injected species. The minimum free energy method is used in determining the species concentrations. The effects of different injection rates, nose radius, and free stream velocities on the convective and radiative heat

transfer are discussed. The results are compared with those from references and they agree quite well with each other. Author

A93-33736
NUMERICAL SIMULATION OF THE TURBULENT DRAG REDUCTION BY PLATE MANIPULATORS
LING QIAN and QIPENG CAO (Nanjing Aeronautical Inst., China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 3 Sept. 1992 p. 300-304. In Chinese. refs

Numerical computation of turbulent drag reduction by plate manipulators within a boundary layer is presented. The code is based on the partially parabolic Navier-Stokes equations together with the J-K turbulence model. Calculations start upstream of the manipulators, including single devices and tandem ones. The results obtained compare well with experiments. Author (revised)

A93-33739
A KIND OF IMPROVED FLUX-SPLIT METHOD FOR SOLVING THE EULER EQUATIONS
ZHENGHONG GAO and QIANGANG LIU (Northwestern Polytechnical Univ., Xian, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 3 Sept. 1992 p. 321-331. In Chinese. refs

A new continuous flux-split method for solving the Euler equations is given in this paper. Steger-Warming's flux splitting method is used, while the improved eigenvalue split method is presented which eliminates the split flux slope discontinuity which appears in the Steger-Warming's approach at some critical points in the flow field. Practical application indicates that this method is rather simple and robust. For the flux split Euler equations, the MUSCL type upwind difference scheme is used and the second order implicit finite volume formulations are built. These formulations are block matrix structures. In order to reduce the computer time, the eigenvector matrix transformation is used so the induced block matrix equations are transformed into separate algebraic equations. It is much easier to solve this kind of equations than the former one, especially in medium or microcomputers. As examples, a quasi-1D nozzle flow with shock and the subsonic and transonic flow about NACA-0012 and NACA64A-10 airfoils are calculated. Numerical application shows that the present method needs less computer storage volume and CPU time. Author (revised)

A93-33741
THE ANALYSIS AND COMPUTATION OF VISCOUS-INVISCID INTERACTIVE PROBLEM FOR THREE DIMENSIONAL TRANSONIC FLOW
GONGBI WEN, XIAOYI HE, WANGYI WU (Beijing Univ., China), and ZUOBIN CHEN (China Aerodynamics Research and Development Center, Mianyang) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 3 Sept. 1992 p. 339-346. In Chinese. refs

In this paper we analyze the viscous-inviscid interactive problem for 3D transonic flow. A suitable choice of inputs for the boundary layer equations in the transonic regime was proved. Based on the multigrid of FL027, partial fine mesh was implemented. Numerical solutions about M and the F1 wing are presented using the full potential equation and an inverse integral 3D compressible turbulent boundary layer code. Comparison with experimental data shows that the semiinverse code suggested in this paper can be applied to design for weak shock. Author (revised)

A93-33746
A NUMERICAL METHOD OF UNSTEADY SEPARATING FLOW OVER DELTA WINGS
MING YAN and JIGUANG AN (Shanghai Jiao Tong Univ., China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 3 Sept. 1992 p. 373-378. In Chinese. refs

The main purpose of this paper is to explore the developing process of the unsteady separating flow over a Delta wing when its angle of attack suddenly changes and to establish a new numerical method to calculate the unsteady flow parameters and aerodynamic forces. After the angle of attack changes, the strength, shape, and position of the leading-edge vortex sheet are continuously changed in addition to the shedding and roll up of the wake. It becomes more complicated to calculate the unsteady separating flow than the attached flow. A numerical method considering the time history of the developing process of the leading-edge and trailing-edge vortex sheets is presented. The calculation results show the stability and efficiency of this method, and it will be helpful to the study on the unsteady aerodynamic forces of the wing with leading-edge separating vortices in unsteady motion. Author (revised)

A93-33747
STUDIES OF THE DYNAMIC STALL PROBLEM ON AIRFOILS
DENGBIN TANG (Nanjing Aeronautical Inst., China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 3 Sept. 1992 p. 379-384. In Chinese. refs

The problem of the unsteady dynamic stall of airfoils oscillating rapidly in pitch and pitbed is studied computationally in this paper. The zonal numerical method, which is used in simulating efficiently and correctly the flowfield surrounding airfoils and achieves high solution accuracy, can save significant computational time, which is very important for studing the unsteady viscous flow problem. In the present research the leading edge stagnation zone is divided separately, and flowfields in the vicinity of the leading edge, on which the leading edge dynamic stall vortex is generated, are computed accurately. Examples give the process of the formation and change of dynamic stall flowfields and the effect on the aerodynamic characteristics. Computed results are shown to be in good agreement with available experiment data. Author (revised)

A93-33748
VISCOUS-INVISCID INTERACTION COUPLED CALCULATION OF THREE-DIMENSIONAL TURBULENT SEPARATED FLOW OVER DENTS
XIA MA (Chinese Academy of Sciences, Inst. of Mechanics, Beijing, China) and ZIQIANG ZHU (Beijing Univ. of Aeronautics and Astronautics, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 3 Sept. 1992 p. 385-389. In Chinese. refs

A coupled calculation for the viscous-inviscid interaction of 3D separated flow over dents at low speed has been made. The inverse boundary layer method is analyzed and discussed and it is verified by the numerical experiments that the integral equation of the inverse boundary layer method is hyperbolic when H and a are given. An approximate numerical characteristic method is proposed. The outer inviscid flow is solved with potential panel method. The computational results show that the 3D boundary layer separated flow with strong 3D effect can be obtained with the present method. Author (revised)

A93-33752
PARAMETRICAL INVESTIGATION OF THE INTERACTION BETWEEN TURBULENT WALL SHEAR LAYERS AND NORMAL SHOCK WAVES, INCLUDING SEPARATION
J. K. KALDELLIS (Inst. for the Development and Management of Natural Resources, Athens, Greece) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202) vol. 115, no. 1 March 1993 p. 48-55. refs
Copyright

The fast energy-type integral method presented in conjunction with an approximate shock-turbulent shear layer interaction procedure is based on the two-zone model, and is able to predict attached and fully detached shear flows. An effort is made to estimate the influence of the inlet Mach number, the shear layer characteristics, and the confinement of the geometry on the static pressure field. Attention is given to the method's application to a one-stage high pressure supersonic flow compressor with normal shock appearance within the rotor. The displacement thickness and form factor shear layer characteristics have a dominant effect on the flow field near the interaction region. AIAA

A93-33755* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRFOIL SHAPE OPTIMIZATION USING SENSITIVITY ANALYSIS ON VISCOUS FLOW EQUATIONS
MOHAMED E. ELESHAKY and OKTAY BAYSAL (Old Dominion Univ., Norfolk, VA) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202) vol. 115, no. 1 March 1993 p. 75-84. ASME, Winter Annual Meeting, Symposium on Multidisciplinary Applications of Computational Fluid Dynamics, Atlanta, GA, Dec. 1-5, 1991 refs
(Contract NAG1-1188)
Copyright

An aerodynamic shape optimization method has previously been developed by the authors using the Euler equations and has been applied to supersonic-hypersonic nozzle designs. This method has also included a flowfield extrapolation (or flow prediction) method based on the Taylor series expansion of an existing CFD solution. The present paper reports on the extension of this method to the thin-layer Navier-Stokes equations in order to account for the viscous effects. Also, to test the method under highly nonlinear conditions, it has been applied to the transonic flows. Initially, the success of the flow prediction method is tested. Then, the overall method is demonstrated by optimizing the shapes of two supercritical transonic airfoils at zero angle of attack. The first one is shape optimized to achieve a minimum drag while obtaining a lift above a specified value. Whereas, the second one is shape optimized for a maximum lift while attaining a drag below a specified value. The results of these two cases indicate that the present method can produce successfully optimized aerodynamic shapes. Author

A93-33757
REAL GAS EFFECTS FOR COMPRESSIBLE NOZZLE FLOWS
D. DRIKAKIS and S. TSANGARIS (Athens National Technical Univ., Greece) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202) vol. 115, no. 1 March 1993 p. 115-120. refs
Copyright

Numerical simulation of compressible nozzle flows of real gas with or without the addition of heat is presented. A generalized real gas method, using an upwind scheme and curvilinear coordinates, is applied to solve the unsteady compressible Euler equations in axisymmetric form. The present method is an extension of a previous 2D method, which was developed to solve the problem for a gas having the general equation of state in the form p=p (rho, i). In the present work the method is generalized for an arbitrary P-V-T equation of state introducing an iterative procedure for the determination of the temperature from the specific internal energy and the flow variables. The solution procedure is applied for the study of real gas effects in n axisymmetric nozzle flow. Author (revised)

A93-33931*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A METHOD OF PREDICTING QUASI-STEADY AERODYNAMICS FOR FLUTTER ANALYSIS OF HIGH SPEED VEHICLES USING STEADY CFD CALCULATIONS
ROBERT C. SCOTT (NASA, Langley Research Center, Hampton, VA) and ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 595-603. refs
(AIAA PAPER 93-1364) Copyright

High speed linear aerodynamic theories like piston theory and Newtonian impact theory are relatively inexpensive to use for flutter analysis. These theories have limited areas of applicability depending on the configuration and the flow conditions. In addition, these theories lack the ability to capture viscous, shock and real gas effects. CFD methods can model all of these effects accurately, but the unsteady calculations required for flutter are expensive and often impractical. This paper describes a method for using steady CFD calculations to approximate the generalized aerodynamic forces for a flutter analysis. Example two-and three-dimensional aerodynamic force calculations are provided. In addition, a flutter analysis of a NASP-type wing will be discussed. Author

A93-33935*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC AEROELASTIC INSTABILITY RESULTS FOR A NASP-LIKE WING MODEL
STANLEY R. COLE, JAMES R. FLORANCE, LEE B. THOMASON (NASA, Langley Research Center, Hampton, VA), CHARLES V. SPAIN, and ELLEN P. BULLOCK (Lockheed Engineering and Sciences Co., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 638-647. refs
(AIAA PAPER 93-1369) Copyright

Two wing-alone wind-tunnel models were tested in the NASA Langley Unitary Plan Wind Tunnel facility to study the static divergence behavior of such configurations and to provide a data base for correlation with supersonic analytical predictions. One model had a four percent maximum thickness airfoil and the other had an eight-percent maximum thickness airfoil. The wing models had low aspect ratios and highly swept leading edges. Results show that decreasing airfoil thickness, moving the wing-pivot location upstream, or increasing the pitch-pivot stiffness have the beneficial effect of increasing the divergence dynamic pressures. The calculations accurately predicted the trend of experimental divergence dynamic pressure with Mach number. AIAA

A93-34120#
NONPLANAR DOUBLET-POINT METHOD FOR SUPERSONIC UNSTEADY AERODYNAMICS
ASHISH TEWARI (National Aeronautical Lab., Bangalore, India) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2466-2476. Research supported by McDonnell Aircraft Co refs
(AIAA PAPER 93-1588) Copyright

A new method is devised for the calculation of pressures and aerodynamic influence-coefficients on nonplanar lifting-surface configurations oscillating in a supersonic freestream. The method is an extension of the methodology introduced in the planar supersonic Doublet-Point scheme of Ueda and Dowell, which is based upon the concept of concentrated lift forces and uses the acceleration potential doublet as an elementary solution of the wave equation. These features make the method capable of being incorporated in a unified code for both subsonic and supersonic speeds, as well as amenable to rapid aeroelastic calculations. Results on various lifting-surface configurations are in agreement with other supersonic oscillatory methods, validating the Doublet-Point approximation for nonplanar supersonic case. Author

A93-34121#
THE ROLE OF KUTTA WAVES ON OSCILLATORY SHOCK MOTION ON AN AIRFOIL EXPERIENCING HEAVY BUFFETING
B. H. K. LEE, H. MURTY (National Research Council of Canada, Inst. for Aerospace Research, Ottawa), and H. JIANG (Queen's Univ., Kingston, Canada) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2477-2489. Research supported by National Research Council of Canada, DND, and NSERC refs
(AIAA PAPER 93-1589) Copyright

An investigation of wave propagation in transonic flows is carried

out using the nonlinear transonic small disturbance equation. The wavefronts are computed from numerical integration of the characteristic equation. The manner in which downstream disturbances, initiated at an airfoil trailing edge, affect the shock wave is analyzed. The propagation time for downstream disturbances to reach the shock wave is computed for various airfoil geometries and free stream Mach numbers. The results are compared to those obtained from an empirical formulation given by Tijdeman. The interaction of upstream moving waves with a time-dependent flowfield is studied for an airfoil performing trailing-edge flap oscillations. The variation of the disturbance amplitude along the wavefront at various instances of time is given for an impulse source at the trailing edge using the method of asymptotic expansion. Author

A93-34122*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXTENSION OF A NONLINEAR SYSTEMS THEORY TO GENERAL-FREQUENCY UNSTEADY TRANSONIC AERODYNAMIC RESPONSES
WALTER A. SILVA (NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2490-2503. refs
(AIAA PAPER 93-1590) Copyright

A methodology for modeling nonlinear unsteady aerodynamic responses, for subsequent use in aeroservoelastic analysis and design, using the Volterra-Wiener theory of nonlinear systems is presented. The methodology is extended to predict nonlinear unsteady aerodynamic responses of arbitrary frequency. The Volterra-Wiener theory uses multidimensional convolution integrals to predict the response of nonlinear systems to arbitrary inputs. The CAP-TSD (Computational Aeroelasticity Program - Transonic Small Disturbance) code is used to generate linear and nonlinear unit impulse responses that correspond to each of the integrals for a rectangular wing with a NACA 0012 section with pitch and plunge degrees of freedom. The computed kernels then are used to predict linear and nonlinear unsteady aerodynamic responses via convolution and compared to responses obtained using the CAP-TSD code directly. The results indicate that the approach can be used to predict linear unsteady aerodynamic responses exactly for any input amplitude or frequency at a significant cost savings. Convolution of the nonlinear terms results in nonlinear unsteady aerodynamic responses that compare reasonably well with those computed using the CAP-TSD code directly but at significant computational cost savings. Author

A93-34123*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL UNSTEADY PRESSURES AT FLUTTER ON THE SUPERCRITICAL WING BENCHMARK MODEL
BRYAN E. DANSBERRY, MICHAEL H. DURHAM, ROBERT M. BENNETT, JOSE A. RIVERA, WALTER A. SILVA, CAROL D. WIESEMAN (NASA, Langley Research Center, Hampton, VA), and DAVID L. TURNOCK (Lockheed Engineering and Sciences Co., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2504-2514. refs
(AIAA PAPER 93-1592) Copyright

This paper describes selected results from the flutter testing of the Supercritical Wing (SW) model. This model is a rigid semispan wing having a rectangular planform and a supercritical airfoil shape. The model was flutter tested in the Langley Transonic Dynamics Tunnel (TDT) as part of the Benchmark Models Program, a multi-year wind tunnel activity currently being conducted by the Structural Dynamics Division of NASA Langley Research Center. The primary objective of this program is to assist in the development and evaluation of aeroelastic computational fluid dynamics codes. The SW is the second of a series of three similar models which are designed to be flutter tested in the TDT on a flexible mount known as the Pitch and Plunge Apparatus. Data sets acquired with these models, including simultaneous unsteady surface pressures and model response data, are meant to be used for correlation with analytical codes. Presented in this report are experimental flutter boundaries and corresponding steady and unsteady pressure distribution data acquired over two model chords located at the 60 and 95 percent span stations. Author (revised)

A93-34124*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY TRANSONIC POTENTIAL FLOW OVER A FLEXIBLE FUSELAGE
MICHAEL D. GIBBONS (Lockheed Engineering and Sciences Co., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2515-2522. refs
(Contract NAS1-19000)
(AIAA PAPER 93-1593)

A flexible fuselage capability has been developed and implemented within version 1.2 of the CAP-TSD code. The capability required adding time dependent terms to the fuselage surface boundary conditions and the fuselage surface pressure coefficient. The new capability will allow modeling the effect of a flexible fuselage on the aeroelastic stability of complex configurations. To assess the flexible fuselage capability several steady and unsteady calculations have been performed for slender fuselages with circular cross-sections. Steady surface pressures are compared with experiment at transonic flight conditions. Unsteady cross-sectional lift is compared with other analytical results at a low subsonic speed and a transonic case has been computed. The comparisons demonstrate the accuracy of the flexible fuselage modifications. Author

A93-34260* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFECT OF AN UNSTEADY THREE-DIMENSIONAL WAKE ON ELASTIC BLADE-FLAPPING EIGENVALUES IN HOVER
DAVID A. PETERS and AY SU (Georgia Inst. of Technology, Atlanta) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38. no. 1 Jan. 1993 p. 45-54. AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings, p. 999-1015. Previously cited in issue 11, p. 1602, Accession no. A90-28228 Research sponsored by U.S. Army refs
(Contract NAG2-462)
Copyright

A93-34273
A STUDY ON TWO-DIMENSIONAL AND THREE-DIMENSIONAL SECONDARY JET INTERACTIONS WITH A SUPERSONIC FLOW
SHIGERU ASO (Kyushu Univ., Fukuoka, Japan), SATOSHI OKUYAMA (Japan Airlines Co., Ltd., Tokyo), YASUNORI ANDO, and TOSHIRO FUJIMORI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160) vol. 52, no. 3 Sept. 1992 p. 289-300. refs

Wind tunnel experiments were conducted at Mach 3.75-3.81, a pressure of 1.2 MPa, and temperatures of 283-299 K in order to investigate shock wave/turbulent boundary layer interaction regions induced by gaseous secondary flows injected into supersonic flows through slot and circular nozzles. The flow fields were visualized by the schlieren method and an oil flow technique, and the surface pressure distributions were measured over the entire interaction region. It is found that the bow shock wave/turbulent boundary layer interaction induces boundary layer separation ahead of the injection point. The separation region, the extent of the interaction region, and shock structures enlarge significantly as the total pressure or the nozzle thickness are increased. A marked difference in the flow structure is observed between slotted and circular injection. AIAA

A93-34274
A STUDY ON THREE-DIMENSIONAL SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION INDUCED BY SWEPTBACK SHARP FINS AT SUPERSONIC FLOW
SHIGERU ASO, SYOZO MAEKAWA (Kyushu Univ., Fukuoka, Japan), and SHIGEHIDE NAKAO (Japan Airlines Co., Ltd., Tokyo)
Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160) vol. 52, no. 3 Sept. 1992 p. 301-310. refs

Shock wave/turbulent boundary layer interaction regions induced by sharp fins with sweptback angles have been experimentally investigated. Experiments are performed at Mach 4, a total pressure of 1.2 MPa, a temperature of 280 K, and a Reynolds number of 2.7 x 10 exp 7. First, surface flows are visualized by oil flow technique, then surface pressure distributions are measured for various sweptback angles of 0, 15, 30, and 45 deg. The major objective of this study is to investigate the effect of the sweptback angle of the leading edge of the fin on the interaction regions of flow fields. The results show that the effect of the sweepback angle of the leading edge is quite significant in terms of reducing the interaction region and peak pressure. Also, the effect of the fin shape is investigated by comparing the present results with the previous results for blunt fins. These results also show that the effect of shape of the leading edge is quite significant in reducing the interaction region and peak pressure.
Author (revised)

A93-34275
NUMERICAL SIMULATION OF STARTING PROCESS IN A HYPERSONIC NOZZLE
MIN-GYOO LEE and MICHIO NISHIDA (Kyushu Univ., Fukuoka, Japan)
Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160) vol. 52, no. 3 Sept. 1992 p. 311-323. refs

The unsteady starting process of an axisymmetric hypersonic nozzle in a shock tunnel is simulated by using a second order upwind TVD scheme of Harten-Yee type. In addition, the bursting process of a diaphragm mounted at shock tube end wall is numerically simulated. The calculated results illustrate the formation mechanism of a rearward facing secondary shock wave, and the behavior of shock waves and a contact surface propagating in a convergent-divergent nozzle. The simulated results indicate that the use of a minmod limiter with artificial compressibility is inadequate for simulating the nozzle starting process because of the appearance of a nonphysical expansion shock in a strong expansion region in the vicinity of the throat. Also, the comparison of the calculated pitot pressure with the measured one shows a fairly good agreement. The results suggest that the present numerical method provides a satisfactory simulation of the starting process in a hypersonic nozzle. Author (revised)

A93-34308
SPREADSHEET MICROCOMPUTER NUMERICAL METHOD FOR THE COMPRESSIBLE LAMINAR WAKE FLOW
ROBERT H. AU (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 1 Swansea, United Kingdom Pineridge Press 1991 p. 127-137. refs

A spreadsheet microcomputer method for solving a rarefied compressible wake behind a long slender cylinder is reported. Closed form integrals involving a Green's function for the momentum and energy equations are solved using the Simpsons's one-third Rule. The comparison of the spreadsheet solution with the previous calculations shows excellent agreement except in the region approaching the freestream. This discrepancy requires further investigation. Author

A93-34318
CALCULATION OF LAMINAR AND TURBULENT ASYMMETRIC WAKES
E. G. TULAPURKARA, S. VENGADESAN, and J. L. NARASIMHAN (Indian Inst. of Technology, Madras, India) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 1 Swansea, United Kingdom Pineridge Press 1991 p. 337-347. Research supported by Centre for Development of Advanced Computing of India refs

The development of symmetric and asymmetric wakes in both laminar and turbulent incompressible flows have been calculated based on a numerical scheme to solve 2D Navier-Stokes equations. In the case of turbulent flows, the standard k-epsilon model of turbulence is used. The results are compared with available data. It is found that the k-epsilon model gives exact results in the near-wake region of symmetric wake without external pressure gradient. In the case of highly asymmetric wake, the calculated results show the shift of the point of minimum velocity with distance as observed in experiments, but the calculated shift is larger. Keeping in view the other calculated results, it can be seen that this over-prediction of the shift is due to underestimation of the turbulent kinetic energy by the standard k-epsilon model.
Author (revised)

A93-34331
EVALUATION OF RNG ALGEBRAIC TURBULENCE MODELS FOR BOUNDARY LAYERS
P. D. THOMAS (Lockheed Research Labs., Palo Alto, CA) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 1 Swansea, United Kingdom Pineridge Press 1991 p. 602-612. Research supported by Lockheed Independent Research Program refs

An existing algebraic turbulence model based on renormalization group theory (RNG) is evaluated and modified. The behavior of the model is investigated analytically for an incompressible boundary layer with an experimentally-determined analytical velocity profile. The model is compared with two well-known algebraic models: the Cebici-Smith model and its derivative, the Baldwin-Lomax model. The Baldwin-Lomax model is found to have a physically unfounded nonuniform behavior as a function of Reynolds number. The RNG model's peak eddy viscosity is about a factor of two lower than that of the Cebici-Smith model, and has a decay that does not reflect the known intermittency of turbulence in the outer part of the boundary layer. We have modified the RNG model parameters analytically to improve its behavior and broaden its range of applicability. Numerical solutions of the Navier-Stokes equations for hypersonic flow using the modified RNG model are found to agree favorably with experimental heat transfer data. Author

A93-34335
VORTEX INITIATION DURING DYNAMIC STALL OF AN AIRFOIL
I. P. ITTY and J. R. LEITH (New Mexico Univ., Albuquerque) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 1 Swansea, United Kingdom Pineridge Press 1991 p. 707-717. Research supported by National Center for Supercomputing Applications refs
(Contract F29601-85-C-0038)

The flow field around an oscillating airfoil is evaluated numerically, using the stream function-vorticity formulation of the Navier-Stokes equations. An algebraic turbulence model, adapted from the Baldwin-Lomax model, is included in solving the time-averaged Reynolds equations. Computed pressure distribution for turbulent flow past a stationary airfoil is compared with measurements. Finally, for the oscillating airfoil cases, the computations are performed in order to determine the history of pressure distribution and to identify the nature of the vortex initiation on the suction surface for laminar and turbulent flow. Our results for laminar flow show that minute circular shaped vortices are formed on the surface prior to the dominant vortex formation.

Flattened vortices are formed on the surface in turbulent flow, prior to the formation of the dominant large vortex structure.
Author

A93-34339
A COMPARISON BETWEEN NUMERICAL MODELS AND MEASUREMENTS IN A KAPLAN TURBINE GUIDE VANES
ANDREJ LIPEJ, DRAGICA JOST, KAZIMIR OBERDANK, and BORIS VELENSEK (Ljubljana Univ., Yugoslavia) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 1 Swansea, United Kingdom Pineridge Press 1991 p. 793-803. refs

In this paper numerical and experimental results of flow analysis in cascade and of flow past a single guide vane are presented. The flow through a cascade and flow past a vane are viscous and incompressible and that is why finite element solver of steady and unsteady Navier-Stokes equations has been developed. Recently the solver has been improved for solving turbulent flow, using van Driest mixing length and Baldwin-Lomax turbulent model. For solving the partial differential equations the finite element method with eight nodal isoparametric elements has been used. Large system of equations is solved using front solution method. Velocity distribution was measured by Laser Doppler Anemometer. LDA measurement gives local value of velocities: mean value and rms of velocity fluctuations. Author

A93-34341
NUMERICAL ANALYSIS OF THE THREE-DIMENSIONAL BOUNDARY LAYER ON A TURBOMACHINERY ROTOR BLADE
J. C. AMORIM and J. L. KUENY (Inst. National Polytechnique, Grenoble, France) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 1 Swansea, United Kingdom Pineridge Press 1991 p. 813-823. refs

A numerical analysis has been developed for calculating viscous flows over arbitrary three-dimensional surfaces by solving the three-dimensional boundary layer equations. The governing equations are written in a general nonorthogonal rotating coordinate system so the Coriolis and centrifugal forces appear explicitly in the equations. The Levy-Lees transformation generalized to three-dimensional flows is utilized. The inviscid properties required at the edge of the boundary layer are obtained from the surface Euler equations. In this preliminary evaluation of the method, a simple algebraic model for Reynolds turbulent stresses is used to close the set of equations. The partial differential equations governing the development of the boundary layer are discretized and approximated by an efficient two-point finite difference numerical scheme. The procedure developed here is validated for some standard test cases and applied to calculate viscous flow over turbine blades. Author

A93-34344
CALCULATION OF THE FLOW AROUND A HIGH-LIFT AIRFOIL USING AN EXPLICIT CODE AND AN ALGEBRAIC REYNOLDS STRESS MODEL
L. DAVIDSON (Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique, Toulouse, France) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 852-862. refs

An explicit, compressible, time-marching code and an algebraic Reynolds stress model (ASM) is used to calculate the flow around a high-lift airfoil. This turbulence model is shown to be able to predict stall for an angle of attack of 16 deg, which is in agreement with experiments. The general formulation of the near-wall correction terms in the ASM gives excessively small damping (or none at all) of the shear stress in the separation regions. The simplified form, which assumes walls parallel to the Cartesian velocity components, is used, which predicts results better in agreement with experiments. This damping is found to be very important in that it contributes to the superiority of the ASM over the k-epsilon model. AIAA

A93-34345
COMPARISON OF SEVERAL CONVECTION DISCRETIZATION SCHEMES FOR ALL MACH NUMBER ARBITRARY 2D FLOWS
M. H. KOBAYASHI and J. C. F. PEREIRA (Lisbon Technical Univ., Portugal) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 863-873. refs

A calculation procedure was developed for the solution of viscous compressible fluid flow at all Mach numbers in arbitrary two-dimensional configurations using non-staggered, non-orthogonal grid systems. A primitive variable formulation was chosen and the pressure field is evaluated using an extension of SIMPLE-algorithm in order to calculate compressible as well as incompressible flows. Five convection discretization schemes have been compared for the calculation of compressible, transonic and supersonic flows: the first order upwind, the hybrid central upwind and the following higher schemes: central differences, high order upwind and quadratic upwind. Author

A93-34346
A CELL-VERTEX TVD SCHEME FOR TRANSONIC VISCOUS FLOW
K. P. DIMITRIADIS and M. A. LESCHZINER (Univ. of Manchester Inst. of Science and Technology, United Kingdom) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 874-885. Research supported by Department of Trade and Industry and Ministry of Defence refs

A finite-volume algorithm featuring cell-vertex storage and the Lax-Wendroff time marching scheme is combined with a TVD smoother in order to arrive at a minimally diffusive, non-oscillatory formulation suited to the prediction of transonic viscous and turbulent flows. The baseline algorithm has previously been applied to unseparated and separated turbulent bump and airfoil flows in conjunction with a range of transport models of turbulence and a pressure-gradient-sensitized second-order smoother. This combination does not ensure boundedness. A Roe/Yee-type TVD variant has been chosen and adapted to the cell-vertex framework, to replace the ad hoc second-order smoother. The TVD variant and its adaptation are exposed in detail. The resulting scheme is applied to four test flows, ranging from inviscid oblique-shock reflection to shock-induced turbulent separation. In all cases, the TVD scheme is shown to yield smooth solutions without adverse consequences to accuracy. Author

A93-34347
A TECHNIQUE FOR ACCELERATED CONVERGENCE IN TRANSONIC FLOW
JAI MOHAN (Aeronautical Development Agency, Bangalore, India) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 886-893. refs

A new extrapolation technique is presented to accelerate the convergence rate of an iterative solution of the exact potential flow equation, used in transonic flow computations. The main features of the present acceleration technique are (a) identification of the dominant eigenvalue of an iteration matrix is not required and (b) apart from taking the value of iterates at different intervals of an iteration cycle, the stage where they occur is also considered in obtaining the extrapolated value of the velocity potential after each cycle. This is achieved by expanding the velocity potential

in power of a small parameter denoting the stage of various set intervals of an iteration cycle. This technique needs very little extra memory and minimum changes in existing computer codes. Numerical results indicate that the computational efficiency of the relaxation method is improved significantly. Author (revised)

A93-34348
NUMERICAL SIMULATION OF INVISCID TRANSONIC FLOW OVER TWO-DIMENSIONAL SLENDER BODIES
P. G. ROUSSEAU and E. H. MATHEWS (Pretoria Univ., South Africa) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 894-900. refs
Copyright

A FORTRAN computer program based on the small perturbation equation for inviscid transonic flow over two-dimensional slender bodies at zero incidence was developed. The classical, rather than the popular transonic similarity form of the equation is used. This ensures that the analysis is also valid for purely supersonic flows at Mach numbers close to unity and eliminates the need to determine a suitable transonic similarity parameter. The discretization technique is similar to that normally used for highly non-linear viscous flows, thereby ensuring stability. The rate of convergence is increased using a special technique. Good agreement is obtained with measurements and published results of other numerical procedures. Author

A93-34349
IMPLICIT NUMERICAL SOLUTION OF TRANSONIC FLOWS USING ADAPTATIVE TRIANGULAR GRIDS
J.-Y. TREPANIER, M. REGGIO, and D. AIT-ALI-YAHIA (Ecole Polytechnique, Montreal, Canada) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 901-911. Research supported by NSERC, Centre de Recherche Informatique de Montreal, and ACDI refs
Copyright

An implicit method for the simulation of transonic flows modelled by the time dependent Euler equations has been developed. The main features of the method are the use of a second order version of the Roe flux difference scheme, the development of a robust linearization consistent with Roe's scheme for implicit temporal discretization, the implicit treatment of the boundary conditions and the implementation of an adaptive grid strategy for global efficiency. The efficiency of the proposed methodology is investigated for the circular arc bump configuration and for the RAE2822 profile. Author

A93-34350
AN IMPLICIT TREATMENT OF TWO EQUATIONS TURBULENCE MODELS FOR HIGH SPEED FLOW COMPUTATIONS
G. FRESKOS and D. VANDROMME (Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique, Toulouse, France) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 912-921. Research supported by SNECMA and Formation Internationale Aeronautique et Spatiale refs
Copyright

A new implicit approach for taking into account the stiff source terms of turbulence models is presented. The aim of this technique is to improve the convergence properties of the main numerical scheme. Tests have been performed for supersonic flow over a flat plate. Comparisons with theoretical predictions confirmed the good behavior of the model. The same treatment is also used for the computation of a more realistic high speed flow around an air intake. Author

A93-34351
COMPRESSIBLE FLOW CALCULATIONS USING A TWO-EQUATION TURBULENCE MODEL AND UNSTRUCTURED GRIDS
LUCA STOLCIS and LESLIE J. JOHNSTON (Univ. of Manchester Inst. of Science and Technology, United Kingdom) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 922-932. refs
(Contract CEC-SC1/900369)
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A method for the calculation of compressible turbulent flows using unstructured grids is presented. The time-dependent Reynolds-averaged Navier-Stokes equations are solved by means of an explicit time stepping scheme. A cell-centered finite volume spatial discretization is employed, with nonlinear numerical dissipation being introduced to damp oscillations and to ensure convergence to the steady-state solution. A high-Reynolds number two-equation k-epsilon turbulence model is utilized for the calculation of turbulence quantities. Results are presented for a single element aerofoil at transonic conditions, and for a multielement high-lift aerofoil. Author (revised)

A93-34352
AN EULER CODE WITH NEW ENERGY EQUATION AND NEW ENTHALPY DAMPING APPROACH
L. C. WANG (Nanjing Aeronautical Inst., China), R. REINELT, and F. THIELE (Berlin, Technische Univ., Germany) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 933-943. refs
Copyright

The paper proposes a new variable representing energy and derives a new energy equation. On the basis of the new variable and the new equation, a novel enthalpy damping approach which needs no extra computing time is developed. In combination with the proposed simple multiple-grid method, nonreflective outlet boundary condition, and multiple-stage time stepping scheme, an efficient and accurate 2D Euler code is presented. Results are presented of numerical experiments carried out for the NACA 0012 airfoil with zero angle of attack under M = 0.2, 0.5, 0.72, and 0.8 and with angle of attack of 1.25 deg under M = 0.80. Comparisons with other Euler codes and other numerical methods are made, and good agreement is found. AIAA

A93-34353
REACTING GAS AND SURFACE COUPLING IN HIGH TEMPERATURE AIR FLOWS
C. BRUNO, L. GUARINO, and F. NASUTI (Rome Univ., Italy) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 944-954. refs
Copyright

Results are presented of 2-D, steady numerical simulation of flows of high temperature dissociated air over a catalytically active fiat plate. Different catalysis models are compared to check the effects of gas-surface coupling. Numerical techniques are reported that produce stable solutions and reasonable convergence speed. It is found that while velocity and temperature are rather insensitive to the type of coupling, heat fluxes and species depend on the model chosen. This is especially important for NO, whose small changes may alter subsequent air/fuel ignition. Author

A93-34354
TAKING INTO ACCOUNT SURFACE ROUGHNESS IN COMPUTING HYPERSONIC RE-ENTRY BODY
A. CARRAU (Bordeaux I, Univ., Talence, France), G. GALLICE (CEA, Le Barp, France), and P. LETALLEC (Paris IX, Univ., France) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ.,

CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 955-965. refs
Copyright

A homogenization strategy to accurately take into account the effect of a rough body on an external flow is developed. An axisymmetric laminar flow over a sphere-cylinder geometry for a perfect gas is studied. The present model consists in distinguishing two computational zones separated by a fictitious wall at a given altitude, epsilon. The first in (y is not greater than epsilon) lies low in the boundary layer and contains the surface roughness (small scale), which is taken to be periodic in x in the first approximation. The second in (y is not less than epsilon) (large scale) corresponds to a standard CFD problem. The influence of roughness on the external flow is shown. This influence grows with the size of the roughness. The size of the boundary layer increases with the abscissa, and the roughness amplitude decreases by comparison. AIAA

A93-34355
COMPUTATION OF SUPERSONIC CROSSFLOW SEPARATION USING A NEW PARABOLIZED NAVIER-STOKES CODE
JEAN-MARC MOSCHETTA and DANY VANDROMME (Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique, Toulouse, France) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 991-1002. refs
Copyright

Computational results from a newly developed parabolized Navier-Stokes solver based on an upwind implicit algorithm are compared with an existing set of experimental laminar results. The PNS code has been validated by applying it to three laminar test cases, including flat-plate boundary layer, hypersonic flow past a 15-deg compression corner and a missile body at angle of attack with crossflow separation. Author

A93-34356
NUMERICAL SIMULATION OF HYPERSONIC RAREFIED GAS FLOW OVER BLUNT BODIES
HUI-LI SHEN, YI-PU ZHU, and SHAN-HONG JI (Northwestern Polytechnical Univ., Xian, China) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 1003-1011. Research supported by Chinese Academy of Sciences refs
Copyright

A numerical model capable of predicting hypersonic rarefied gas flow over the shuttle nose in the altitude range of 140 to 990 kms is presented. On the basis of the two-beam approximation, the flow properties of this transitional flow field can be described by a set of time-dependent aerodynamic equations and an interaction relation describing the variation of the mole fraction of one beam of known mean velocity and temperature. A finite element spatial discretization and a Runga-Kutta time marching scheme are used to solve the equations. For axisymmetric flow, the solution domain is divided into 9-node curved isoparametric elements in the meridian plane. Results of sample calculations performed at various Knudsen numbers and Mach numbers are presented and compared with results obtained with the Monte Carlo method. AIAA

A93-34357
NUMERICAL SIMULATION OF TWO-DIMENSIONAL COMPRESSIBLE FLOWS
J. F. MILTHORPE (Univ. College, Campbell, Australia) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 1012-1022. *refs*
Copyright

A simple convection algorithm for simulation of time-dependent supersonic and hypersonic flows of a perfect but viscous gas is described. The algorithm is based on conservation and convection of mass, momentum and energy in a grid of rectangular cells. Examples are given for starting flow in a shock-tube and oblique shocks generated by a wedge, at Mach numbers up to 30.4. Good comparisons are achieved with well-known perfect gas flows. Author

A93-34358
REACTIVE AND DISSIPATIVE HYPERSONIC FLOW IN A WIND TUNNEL NOZZLE
D. ZEITOUN, E. BOCCACCIO, and M. IMBERT (Ax-Marseille I, Univ., Marseille, France) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 1023-1031. refs
Copyright

The present work is a numerical study of reactive, dissipative and laminar hypersonic flow in an axisymmetric wind tunnel nozzle. The air flow is considered as a mixture of five species in a nonequilibrium chemical state and with an equilibrium internal energy. The system of equations, which describes this flow, consists of the Navier-Stokes equations with five equations added for the species of the mixture. These equations are solved by a non-iterative implicit finite difference scheme with a flux splitting technique in the implicit operator. The results show the distribution of the flow parameters along and across different sections of the nozzle and the evolution of the boundary layers. In addition comparisons are made with results obtained using an inviscid flow calculation. Author

A93-34359
COMPUTATION OF TURBULENT COMPRESSIBLE FLOWS ON A DLR WING AND A BLADE TO BLADE PASSAGE USING AN UPWIND SCHEME
G. CAPDEVILLE and V. ROCHERY (Ecole Nationale Superieure de Mecanique, Nantes, France) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 1032-1042. Research supported by DRET refs
Copyright

A numerical code used to solve the compressible Navier-Stokes equations is presented. A finite volume, cell-centered method based on a flux difference-splitting scheme is used to solve the steady-state Navier-Stokes equations. The reconstruction of the flowfield from its cell averaged is performed using an ENO or a TVD procedure. A local time-stepping procedure, an implicit correction of the residuals based on a factored, 'diagonal', implicit operator and a multigrid scheme are used to accelerate the convergence of the numerical procedure to the steady-state. Turbulence effects are modelled with the eddy viscosity concept using a mixing-length model of Baldwin & Lomax. Numerical results are presented and discussed for the turbulent turbomachinery blade to blade flow in a transonic axial-compressor. Author

A93-34360
COMPUTATION OF VISCOUS TRANSONIC AEROFOIL FLOWS USING EDDY-VISCOSITY BASED TURBULENCE MODELS
L. J. JOHNSTON (Univ. of Manchester Inst. of Science and Technology, United Kingdom) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 1043-1054. refs
Copyright

A method to compute the viscous flow development around transonic aerofoil sections is described. The Reynolds-averaged Navier-Stokes equations are solved using a cell-centered finite-volume spatial discretization procedure. The solution is obtained by marching in time to the steady state. Turbulence modelling is at the eddy-viscosity level, with the Baldwin-Lomax algebraic model and a one-equation model as options. Predictions using both models are in good agreement with experiment for fully-attached, or marginally-separated, transonic flows. Significant discrepancies result for more extreme flows, involving

shock-induced or trailing-edge separation. It is anticipated that improved turbulence modelling, via an algebraic Reynolds stress closure, will lead to better predictions from the one-equation model. Author

A93-34362
DYNAMICALLY ADAPTIVE GRID AND ITS APPLICATIONS TO FLOW PROBLEMS
A. TASSA and Y. TASSA (Lockheed Research Labs., Palo Alto, CA) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 1219-1229. Research supported by Lockheed Independent Research Program refs
Copyright

This paper presents a dynamically adaptive grid scheme in conjunction with 2D and 3D Navier-Stokes solvers. The basic idea of the method resides in interpreting the Thompson grid generation method as an arc equidistribution scheme and then determines the control functions in such a way as to provide an adaptive grid. In other words, any elliptic grid generator based upon Thompson's scheme can be converted into an adaptive grid algorithm. To verify the code numerically, the adaptive scheme is applied to the computation of the following complex problems: near wake flow at high Mach number, rocket exhaust plume/air interaction at high altitude, and a 3D flow over an ellipsoid at low subsonic speed. Preliminary numerical results show that better accuracy can be achieved with adaption scheme in regions where high flow field gradients are sustained. Author (revised)

A93-34370
AN INTEGRATED FLOW SIMULATION SYSTEM ON A PARALLEL COMPUTER. I - BASIC CONCEPT. II - THE FLOW SOLVER
S. POKORNY, M. FADEN, and K. ENGEL (DLR, Inst. fuer Antriebstechnik, Cologne, Germany) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 2 Swansea, United Kingdom Pineridge Press 1991 p. 1590-1600. refs
Copyright

The motivation and the layout of an interactive instationary flow simulation system on a parallel computer is described. The principal components required and the mechanisms employed to interact with all the processors are discussed. An analysis of the parallel system's efficiency is presented. Extrapolation of the performance onto more than 40 processors is found to be possible. The design and implementation of a parallel flow solver based on a second-order TVD scheme is described. Different methods of coupling relatively moving grids are discussed. Preliminary results for the supersonic flow through two countermoving cascades are presented. After 2000 timesteps a period state is reached with a relative inflow Mach number of 1.08 for the first cascade. The flow field in the first cascade is completely supersonic whereas the flowfield for the second one is transonic with a small supersonic region. AIAA

A93-34405
TRANSONIC FLOW AROUND THE LEADING EDGE OF A THIN AIRFOIL WITH A PARABOLIC NOSE
Z. RUSAK (Rensselaer Polytechnic Inst., Troy, NY) Journal of Fluid Mechanics (ISSN 0022-1120) vol. 248 March 1993 p. 1-26. refs
(Contract AF-AFOSR-88-0037)
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Matched asymptotic methods are used to analyze a transonic potential flow about the leading edge of a thin airfoil with a parabolic nose. At a fixed transonic similarity parameter asymptotic expansions of the velocity potential function are constructed in terms of the airfoil thickness ratio at an outer region around the airfoil and an inner region near the nose. The matching of the inner and outer expansions results in a well-defined boundary-value problem in the inner region. The numerical solution of the inner flow results in symmetric pressure and velocity distributions on the parabolic nose. A uniformly valid pressure distribution on the entire airfoil surface is derived from the outer and inner solutions. It is concluded that the pressure distribution on the upper and lower surfaces of the airfoil is symmetric near the edge point, and asymmetric deviations increase and become significant only when the distance from the leading edge of the airfoil increases beyond the inner region. AIAA

A93-34415
THE INTERACTION BETWEEN A STEADY JET FLOW AND A SUPERSONIC BLADE TIP
N. PEAKE (Cambridge Univ., United Kingdom) Journal of Fluid Mechanics (ISSN 0022-1120) vol. 248 March 1993 p. 543-566. Research supported by Emmanuel College refs
Copyright

Consideration is given to the lift and radiation generated when a rigid quarter-plane lying in supersonic mean flow intersects a perpendicular velocity jet convected by the mean flow. This is a model problem of relevance to the question of tip-vortex interaction noise produced by modern propellers. AIAA

A93-34483* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFICIENT HYBRID SCHEME FOR THE ANALYSIS OF COUNTER-ROTATING PROPELLERS
R. SRIVASTAVA (NASA, Lewis Research Center, Cleveland, OH) and LAKSHMI N. SANKAR (Georgia Inst. of Technology, Atlanta) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 382-388. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991, AIAA Paper 91-0703. Previously cited in issue 06, p. 802, Accession no. A91-19422 refs
(Contract NAG3-730)
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A93-34484* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MULTIPASSAGE THREE-DIMENSIONAL NAVIER-STOKES SIMULATION OF TURBINE ROTOR-STATOR INTERACTION
N. K. MADAVAN, M. M. RAI (NASA, Ames Research Center, Moffett Field, CA), and S. GAVALI (Fujitsu America, Inc., San Jose, CA) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 389-396. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991, AIAA Paper 91-2464. Previously cited in issue 18, p. 3061, Accession no. A91-44251 Research supported by U.S. Navy refs
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A93-34485
INLET TURBULENCE DISTORTION AND VISCOUS FLOW DEVELOPMENT IN A CONTROLLED-DIFFUSION COMPRESSOR CASCADE AT VERY HIGH INCIDENCE
G. V. HOBSON and R. P. SHREEVE (U.S. Naval Postgraduate School, Monterey, CA) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 397-404. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991, AIAA Paper 91-2004. Previously cited in issue 17, p. 2853, Accession no. A91-41673 Research supported by U.S. Navy refs
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A93-34486
COMPUTATIONS AND EXPERIMENTS FOR A MULTIPLE NORMAL SHOCK/BOUNDARY-LAYER INTERACTION
B. F. CARROLL, P. A. LOPEZ-FERNANDEZ (Florida Univ., Gainesville), and J. C. DUTTON (Illinois Univ., Urbana) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 405-411. Research supported by U.S. Navy refs
Copyright

Results from a numerical investigation of a Mach 1.61 multiple normal shock wave/turbulent boundary-layer interaction are compared to wall static pressure and laser Doppler velocimeter

measurements. The computations used the explicit, time-dependent, second-order accurate MacCormack scheme to solve the mass-averaged Navier-Stokes equations. Turbulence was modeled by means of the Baldwin-Lomax algebraic model and the Wilcox-Rubesin two-equation model. The computation with the Wilcox-Rubesin model was able to capture the major features of the normal shock train and accurately predicted the flow reacceleration mechanisms which occur between shocks. However, this computation failed to accurately predict the level of flow separation under the first shock. The Baldwin-Lomax computation displayed a more limited ability to capture the features of this shock train flow. Author

A93-34487
USING A FULL POTENTIAL SOLVER FOR PROPULSION SYSTEM EXHAUST SIMULATION
ROBIN G. MELVIN, FORRESTER T. JOHNSON, DAVID P. YOUNG, DAVID W. FOUTCH, JOHN E. BUSSOLETTI, and MICHAEL B. BIETERMAN (Boeing Co., Seattle, WA) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 412-421. refs
Copyright

The need for accurate simulations of engine installations on modern commercial transport aircraft has led to consideration of several formulations capable of modeling engine exhausts. Since such exhausts often interact with wings, struts, and nacelles, a complex geometry computational fluid dynamics (CFD) capability is desirable. Engine exhausts often contain nonlinear effects such as weak shock waves. There are very few CFD codes that can model these effects for complex geometries in a timely way. However, a full potential formulation has been implemented in the general geometry code TRANAIR. This model incorporates certain assumptions, the main one being that the flowfield can be divided into a finite number of regions in each of which the total pressure and total temperature are constant. The purposes of this article are to state the theoretical assumptions made by the full potential and Euler models and to validate the methods on an axisymmetric test case. In the situations considered (typical of modern turbofan engines) the full potential and Euler results agree very well. Author

A93-34488* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STUDY ON VORTEX GENERATOR FLOW CONTROL FOR THE MANAGEMENT OF INLET DISTORTION
BERNHARD H. ANDERSON (NASA, Lewis Research Center, Cleveland, OH) and JAMES GIBB (Defence Research Agency, Bedford, United Kingdom) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 422-430. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3177. Previously cited in issue 23, p. 4052, Accession no. A92-54013 refs
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A93-34489* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMMERCIAL TURBOFAN ENGINE EXHAUST NOZZLE FLOW ANALYSES
KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, VA), K. UENISHI, B. D. KEITH (GE Aircraft Engines, Cincinnati, OH), and JOHN R. CARLSON (NASA, Langley Research Center, Hampton, VA) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 431-436. AIAA Applied Aerodynamics Conference, 10th, Palo Alto, CA, June 22-24, 1992, Technical Papers. Pt. 2, p. 736-745. Previously cited in issue 19, p. 3250, Accession no. A92-45543 refs
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A93-34490* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMPUTATIONAL STUDY OF ADVANCED EXHAUST SYSTEM TRANSITION DUCTS WITH EXPERIMENTAL VALIDATION
C. WU, S. FAROKHI, and R. TAGHAVI (Kansas Univ., Lawrence) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 437-442. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3794. Previously cited in issue 20, p. 3554, Accession no. A92-49126 Research supported by GE Aircraft Engines refs
(Contract NAG3-841)
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A93-34491
NONREFLECTING BOUNDARY CONDITIONS OF THREE-DIMENSIONAL EULER EQUATION CALCULATIONS FOR STRUT CASCADES
K. IMANARI and H. KODAMA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 443-448. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3045. Previously cited in issue 20, p. 3471, Accession no. A92-48705 refs
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A93-34499
CONVENIENT METHOD TO CONVERT TWO-DIMENSIONAL CFD CODES INTO AXISYMMETRIC ONES
SHENG-TAO YU (Sverdrup Technology, Inc., Brook Park, OH) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 493-495.

The present systematic procedure for conversion of 2D CFD codes into axisymmetric ones organizes the governing equations in a form suitable for CFD application and examines the volume and surface area calculations of the axisymmetric control-volume element. While this discussion is restricted to the finite-volume method, a similar procedure could be applied to finite-difference codes. AIAA

A93-35160#
COMPARISON OF ELECTROSTATIC AND AERODYNAMIC FORCES DURING PARACHUTE OPENING
M. HORENSTEIN (Boston Univ., MA) and N. ROBERTS (U.S. Army, Natick Research, Development, and Engineering Center, MA) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 72-78. Research sponsored by U.S. Army refs
(AIAA PAPER 93-1210) Copyright

The work reported here seeks to determine the conditions, if any, under which electrostatic effects become comparable to aerodynamic forces during parachute opening. A simple Bernoulli model is used to estimate the principal aerodynamic forces during the early stages of inflation. The electrostatic forces during this period are found by computing the Coulomb attraction between two folds of parachute cloth charged to opposite polarity. These attractive Coulomb forces produce an inward 'electrostatic tension' that acts to oppose the outwardly directed tension caused by the Bernoulli pressure. The investigation involves theoretical analysis, small-scale wind tunnel tests, and extrapolations to full-size parachutes. Our present estimates suggest that aerodynamic forces are two to three orders of magnitude larger man electrostatic forces for typical levels of air velocity and charge density. Typical levels of charge density are defined as those easily obtained in the laboratory via the process of triboelectrification (creation of static charge by friction). Author

A93-35165#
EXPERIMENTAL VALIDATION OF A DISCRETE VORTEX METHOD FOR INVISCID AXISYMMETRIC FLOW AROUND PARACHUTE CANOPIES
Y. FRUCHT, N. HAZAN (Rafael Armament Development Authority, Haifa, Israel), and D. LEVIN (Technion - Israel Inst. of Technology, Haifa) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United

Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 114-124. refs
(AIAA PAPER 93-1216) Copyright

An experimental validation of a previously reported numerical method for the investigation of the flow around axisymmetrical rigid parachute canopies is presented. The validation is performed through visualization studies in a water-tunnel and force, velocity, and pressure measurements in a wind tunnel. The flow visualization explores the main structure of the wake flow behind a solid hemisphere for both steady and unsteady conditions of the free flow. The wake flow was characterized by a periodic shedding of vortex-ring clusters. The Strouhal number of this shedding was 0.1 in the water tunnel experiment, as compared to the value of 0.13 predicted by the numerical method. Both experiment and computation show that the free stream unsteadiness suppresses the wake flow periodicity. Wind tunnel tests, which included hot wire anemometry aimed at measuring the periodicity of the vortex cluster shedding, resulted in a Strouhal number of 0.14. Force and pressure distribution measurements compared well with the predictions of the numerical method. Author (revised)

A93-35169#
PRANDTL THEORY APPLIED TO PARAGLIDER AERODYNAMICS
M. A. GONZALEZ (CIMSA, Madrid, Spain) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 166-171. refs
(AIAA PAPER 93-1220) Copyright

An application of the Prandtl Lifting Line Theory to the study of the aerodynamics of paragliders is presented. It is assumed that the paraglider can be idealized by a horseshoe vortex distribution along a curved line, which is the 1/4 line of the paraglider. The whole formulation is presented following the Multhopp Method to solve the integral equation generated by the Prandtl problem. Results are compared with those obtained with a Vortex Lattice Method specially developed for curved wings; agreement between both procedures is founded to be very good. Author

A93-35173#
METHODS AND RESULTS OF THEORETICAL INVESTIGATIONS FOR HIGH-SPEED PARACHUTE SYSTEMS
IURII V. MOSEEV (Scientific-Research Inst. of Parachute Construction, Moscow, Russia) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 194-203. refs
(AIAA PAPER 93-1227) Copyright

The latest theoretical investigations performed in Russia for high-speed parachute systems are discussed. Extended numerical, analytical, and asymptotical methods are considered. Results of theoretical simulations are compared with empirical data. The supersonic parachute drag coefficient definition problem is highlighted. AIAA

A93-35175#
IMPULSE GUIDED SAMARA DECELERATOR
DANIEL W. PILLASCH and DANIEL W. PANGBURN (Aerojet, Electronic Systems Div., Azusa, CA) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 215-227. refs
(AIAA PAPER 93-1234) Copyright

This paper describes the analysis, design, and test of 13.6 kg (30 lb) scanning body under a samara-wing decelerator using impulse thrusters for mid-course lateral divert. Preliminary tests were conducted without thrusters to correlate drop test results with analytic models and with vertical wind tunnel tests. The underlying design equations and data analysis are presented. The tests with a thruster demonstrate that a Samara-wing decelerator system can be impulsively guided while maintaining stable coning motion throughout, and after, the thrusted period. Author

A93-35177#
APPARENT MASS EFFECTS ON PARAFOIL DYNAMICS
P. B. S. LISSAMAN (Southern California Univ., Los Angeles, CA) and GLEN J. BROWN (Vertigo, Inc., Lake Elsinore, CA) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 233-239. refs
(AIAA PAPER 93-1236) Copyright

Apparent mass has a strong effect on the flight dynamics of lightly-loaded flight vehicles such as parafoils. The calculation of the components of apparent mass and moment and the application of these quantities to the associated forces applied to the vehicle is, in many cases, nonintuitive. The paper discusses the theory and application of apparent mass to a fixed-geometry body moving through a fluid and methods for calculating the apparent mass of a parafoil. Approximate methods are proposed, in parametric form, that allow rapid estimates of the apparent mass of a parafoil with useful accuracy. Author

A93-35181#
THE STABILITY AND AERODYNAMIC PERFORMANCES OF CLUSTERS OF SMALL CRUCIFORM PARACHUTES
P. M. RENDER and P. R. COULTER (Loughborough Univ. of Technology, United Kingdom) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 255-261. Research supported by Irvin Great Britain, Ltd refs
(AIAA PAPER 93-1242) Copyright

Wind tunnel tests have been carried out to determine the drag and stability characteristics of clusters of three small cruciform parachutes. The effect of varying canopy riser length, tethered length and body riser length was investigated. It was concluded that it is possible to produce a stable cluster system using cruciform parachutes. The most significant improvement in cluster drag characteristics came from increasing the canopy riser length. Changing the length of the tethers produced no changes in either the drag or stability characteristics. Finally, it was shown that clusters of cruciform parachutes can produce efficiency factors similar to those obtained for other types of parachutes. Efficiency factor was defined as cluster drag coefficient divided by drag coefficient of a parachute when flown singly. Author

A93-35185#
INFLUENCE OF THE CANOPY-PAYLOAD COUPLING ON THE DYNAMIC STABILITY IN PITCH OF A PARACHUTE SYSTEM
DAVID J. COCKRELL and N. I. A. HAIDAR (Leicester Univ., United Kingdom) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 289-295. refs
(AIAA PAPER 93-1248) Copyright

The influence of the canopy-payload coupling on the dynamic stability in the pitch of a parachute system is examined, with emphasis on the circumstances under which a canopy such as the disk-gap-band, which at its equilibrium angle of attack is weakly statically unstable in pitch, promote dynamic instability in the payload to which it is coupled. With the system described by Doherr and Saliaris (1987), if the canopy is rigidly coupled to the payload, there is no damping of the payload oscillations in pitch. With such a system there is a need to ensure aerodynamic damping of the payload's oscillations. If there is a free coupling between the canopy and the payload, a statically stable parachute canopy can stabilize the payload. AIAA

A93-35266
UNSTEADY SUPERSONIC FLOW AROUND A BLUNT BODY IN THERMAL INHOMOGENEITIES IN TURBULENT SHOCK LAYER FLOWS [NESTATSIONARNOE SVERKHZVUKOVOE OBTEKANIE ZATUPLENNOGO TELA V TEPLOVYKH NEODNORODNOSTIAKH PRI TURBULENTNOM REZHIME TECHENIIA V UDARNOM SLOE]
IU. P. GOLOVACHEV and V. V. ZEMLIAKOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669) vol. 33, no. 1 Jan. 1993 p. 151-155. In Russian. refs
Copyright

Unsteady turbulent supersonic flow around a sphere moving through thermal inhomogeneities is investigated numerically using a viscous shock layer model. It is shown that the flow is characterized by significant changes in the shape of the head shock, occurrence of internal shock waves and high-temperature jets in the shock layer, and substantial changes in the distribution of drag and heat transfer parameters on the body surface. The behavior of the heat flow on the body surface is affected to the greatest extent by the laminar-turbulent transition. AIAA

A93-35268
A STUDY OF FLOW STRUCTURE AND HEAT TRANSFER INTENSITY IN THE VICINITY OF AN EXPANDING STEP ON A PLATE [ISSLEDOVANIE STRUKTURY TECHENIIA I INTENSIVNOSTI TEPLOOBMENA V OKRESTNOSTI RASSHIRIAIUSHCHEGOSIA USTUPA NA PLASTINE]
V. M. TROFIMOV and S. I. SHTREKALKIN (RAN, Inst. Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, Russia) Sibirskii Fiziko-Tekhnicheskii Zhurnal (ISSN 0869-1339) no. 6 Nov.-Dec. 1992 p. 126-132. In Russian. refs
Copyright

Wind tunnel experiments were carried out to investigate flow in the vicinity of an expanding step on a plate in order to further refine a physical model of such flows and to characterize the heat transfer processes. The structure of the flow is determined by using various flow visualization methods. Local maxima of heat transfer intensity are detected along the reattachment lines behind the slanted sides of the step. The maxima exceed heat transfer ahead of the step by 50 percent and that in the reattachment region by 11 percent. AIAA

A93-35270
HYDRODYNAMICS AND HEAT TRANSFER NEAR THE STAGNATION POINT IN AN ARBITRARY AXISYMMETRIC NONSWIRLING FLOW INCIDENT ON A ROTATING OBSTACLE [GIDRODINAMIKA I TEPLOOBMEN VBLIZI TOCHKI TORMOZHENIIA PRI NATEKANII PROIZVOL'NOGO OSESIMMETRICHNOGO NEZAKRUCHENNOGO POTOKA NA VRASHCHAIUSHCHUIUSIA PREGRADU]
IU. P. SAVEL'EV, N. V. TARASOVA, and IU. M. TSIRKUNOV (Sankt-Peterburgskii Mekhanicheskii Inst., St. Petersburg, Russia) Sibirskii Fiziko-Tekhnicheskii Zhurnal (ISSN 0869-1339) no. 6 Nov.-Dec. 1992 p. 126-132. In Russian. refs
Copyright

A method proposed in an earlier study (Tsirkunov and Tarasova, 1990) for two-dimensional flows is extended to the analysis of a three-dimensional axisymmetric nonswirling flow incident on a rotating obstacle. By using this approach, the structure and some functionals (friction coefficient, friction moment, and heat transfer) of the flow are studied in a systematic manner over a wide range of the governing parameters (the temperature factor and the dimensionless rotation velocity of the obstacle). AIAA

A93-35339
CALCULATION OF THE IRREGULAR INTERACTION OF SHOCK WAVES [K RASCHETU NEREGULIARNOGO VZAIMODEISTVIIA UDARNYKH VOLN]
I. S. BELOTSERKOVETS and V. I. TIMOSHENKO PMTF - Prikladnaia Mekhanika i Tekhnicheskaia Fizika (ISSN 0044-4626) no. 6 Nov.-Dec. 1992 p. 9-14. In Russian. refs
Copyright

The problem of the irregular Mach interaction (reflection) of shock waves is investigated analytically. By using a formulation proposed in an earlier study (Belotserkovets and Timoshenko, 1984), the Mach interaction of shock waves is calculated with allowance for gas viscosity. The analysis employs a simplified Prandtl formula for turbulent viscosity, with a proportionality factor of 0.03. The results are presented in graphic form. AIAA

A93-35344
A STUDY OF THE TEMPERATURE OF BODIES IN THE FLOW-AROUND REGIME IN THE CASE OF SURFACE GAS INJECTION [ISSLEDOVANIE TEMPERATURNYKH REZHIMOV OBTEKAEMYKH TEL PRI VDUVE GAZA S POVERKHNOSTI]
V. I. ZINCHENKO, A. G. KATAEV, and A. S. IAKIMOV PMTF - Prikladnaia Mekhanika i Tekhnicheskaia Fizika (ISSN 0044-4626) no. 6 Nov.-Dec. 1992 p. 57-64. In Russian. refs
Copyright

The problem of heating in the case of supersonic flow of air around a blunt cone is solved with allowance for different flow regimes in the boundary layer and gas injection from the spherical blunt section of the cone. In particular, attention is given to the effects of the flow regimes and flow rate coefficients of the injected gas, geometry of the shell, and thermophysical properties of the body material on the characteristics of unsteady coupled heat and mass transfer. The results of the study can be used in interpreting results of aerodynamic tests. AIAA

A93-35346
INTERMODE EXCHANGE IN A SUPERSONIC BOUNDARY LAYER [MEZHMODOVYI OBMEN V SVERKHZVUKOVOM POGRANICHNOM SLOE]
A. V. FEDOROV and A. P. KHOKHLOV PMTF - Prikladnaia Mekhanika i Tekhnicheskaia Fizika (ISSN 0044-4626) no. 6 Nov.-Dec. 1992 p. 67-72. In Russian. refs
Copyright

The initial stage of the laminar-turbulent transition in a boundary layer is characterized by the development of unstable modes. Here, the intermode exchange near the spectrum bifurcation points is analyzed for a supersonic boundary layer. A boundary layer on a plate in supersonic flow of an ideal gas is considered as an example. The results of the analysis are sufficiently general and can be applied to other classes of unstable weakly nonparallel flows. AIAA

A93-35486* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TEMPERATURE AND SUCTION EFFECTS ON THE INSTABILITY OF AN INFINITE SWEPT ATTACHMENT LINE
D. G. LASSEIGNE, T. L. JACKSON, and F. Q. HU (Old Dominion Univ., Norfolk, VA) Physics of Fluids A (ISSN 0899-8213) vol. 4, no. 9 Sept. 1992 p. 2008-2012. Research supported by Old Dominion Univ. refs
(Contract NAS1-18605; AF-AFOSR-91-0180; NSF DMS-90-07642)
Copyright

It is known that the incompressible, infinite swept attachment line flow is unstable to streamwise disturbances that originate in the boundary layer when the cross-flow exceeds a critical magnitude. Furthermore, a small degree of suction at the surface has a significant stabilizing influence while a small degree of blowing has a considerable destabilizing influence. This paper investigates the stabilizing and destabilizing effects of, respectively, cooling or heating the plate and the competing or enhancing effects of suction or blowing. A nonorthogonal flow with respect to the attachment line is also considered by adding a component of shear to the mean flow. Author

A93-35607* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPLICIT UPWIND SOLUTION ALGORITHMS FOR THREE-DIMENSIONAL UNSTRUCTURED MESHES
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) *AIAA Journal* (ISSN 0001-1452) vol. 31, no. 5 May 1993

p. 801-805. Previously announced in STAR as N92-30691 refs
Copyright

The development of implicit upwind algorithms for the solution of the three-dimensional, time-dependent Euler equations on unstructured tetrahedral meshes is described. The implicit temporal discretization involves either a two-sweep Gauss-Seide relaxation procedure, a two-sweep Point-Jacobi relaxation procedure, or a single-sweep Point-Implicit procedure; the upwind spatial discretization is based on the flux-difference splitting of Roe. Detailed descriptions of the three implicit solution algorithms are given, and calculations for the Boeing 747 transport configuration are presented to demonstrate the algorithms. Advantages and disadvantages of the implicit algorithms are discussed. A steady-state solution for the 747 configuration, obtained at transonic flow conditions using a mesh of over 100,000 cells, required less than one hour of CPU time on a Cray-2 computer, thus demonstrating the speed and robustness of the general capability. Author

A93-35609
HYPERSONIC NONEQUILIBRIUM FLOW COMPUTATIONS USING THE ROE FLUX-DIFFERENCE SPLIT SCHEME
ESWAR JOSYULA, DATTA GAITONDE, and JOSEPH S. SHANG (USAF, Flight Dynamics Directorate, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 812, 813. AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991, AIAA Paper 91-1700. Previously cited in issue 18, p. 3055, Accession no. A91-43599 refs

A93-35612* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESULTS FROM A CONICAL EULER METHODOLOGY DEVELOPED FOR UNSTEADY VORTICAL FLOWS
ELIZABETH M. LEE and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 818, 819. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991, AIAA Paper 91-0730. Previously cited in issue 06, p. 802, Accession no. A91-19438 refs
Copyright

A93-35613* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CALCULATION OF COMPRESSIBLE BOUNDARY LAYERS BY A HYBRID FINITE ELEMENT METHOD
ANDREW J. MEADE, JR. (Rice Univ., Houston, TX) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 820-825. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0524. Previously cited in issue 10, p. 1548, Accession no. A92-26948 refs
(Contract NAG1-1196)
Copyright

A93-35621* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STUDY OF SUPERSONIC INTERSECTION FLOWFIELD AT MODIFIED WING-BODY JUNCTIONS
B. LAKSHMANAN and S. N. TIWARI (Old Dominion Univ., Norfolk, VA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 877-883. refs
(Contract NAG1-530)
Copyright

The problem of supersonic flow control using fillets and sweep for a wing-body junction has been investigated numerically using a three-dimensional Navier-Stokes code, which employs the MacCormack's time-split finite volume technique. An elliptic grid generation technique with direct control over spacing has been developed for constructing the grid at a filleted wing-body junction. The computed results for pressure distribution, particle paths, and limiting streamlines on the flat plate and fin surface for a swept fin show a decrease in the peak pressure on the fin leading edge and in the extent of the separated flow region. Moreover, the results for filleted juncture clearly show that the flow streamline patterns lose much of their vortical character with proper filleting. It has been demonstrated that fillets with a radius of three-and-one-half times the fin leading-edge diameter are required to weaken the vorticity in the horseshoe vortex by a factor of three for the Mach number and Reynolds number considered in the present study. Author

A93-35623
DEFORMING GRID VARIATIONAL PRINCIPLE FOR UNSTEADY SMALL DISTURBANCE FLOWS IN CASCADES
KENNETH C. HALL (Duke Univ., Durham, NC) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 891-900. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0665 refs
Copyright

A93-35634* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TURNS - A FREE-WAKE EULER/NAVIER-STOKES NUMERICAL METHOD FOR HELICOPTER ROTORS
G. R. SRINIVASAN and J. D. BAEDER (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 959-961. refs
(Contract DAAL03-90-C-0013)

Computational capabilities of a numerical procedure, called TURNS (transonic unsteady rotor Navier-Stokes), to calculate the aerodynamics and acoustics (high-speed impulsive noise) out to several rotor diameters are summarized. The procedure makes it possible to obtain the aerodynamics and acoustics information in one single calculation. The vortical wave and its influence, as well as the acoustics, are captured as part of the overall flowfield solution. The accuracy and suitability of the TURNS method is demonstrated through comparisons with experimental data. AIAA

A93-35635
CORRELATION OF CONICAL INTERACTIONS INDUCED BY SHARP FINS AND SEMICONES
XUE-YING DENG and JIN HUA LIAO (Beijing Univ. of Aeronautics and Astronautics, China) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 962, 963. AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991, AIAA Paper 91-1756. Previously cited in issue 17, p. 2858, Accession no. A91-42577 Research supported by NNSFC and National Education Committee Sciences Fund refs
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A93-35636
OBLIQUE SHOCK FORMATION IN IMPULSIVELY STARTED WEDGE FLOWS
J. FALCOVITZ (Technion - Israel Inst. of Technology, Haifa), Y. KIVITY (Rafael Armament Development Authority, Ballistic Center, Haifa, Israel), and D. WEIHS (Technion - Israel Inst. of Technology, Haifa) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 964-966. refs
Copyright

An alternative, accurate model for the rate of formation of the oblique shock to the model developed by Weihs and Freitas (WF) is presented. The crucial element missing in the WF model is the incorporation of the incorporation of the curve transition segment of the forming shock into the model. It is found that the transition segment can be accounted for approximately without explicitly resorting to curved shock analysis. The approximation was performed by considering solely the end-point of the curved shock, which also denotes the beginning of the normal stopping shock. AIAA

N93-24736*# Eloret Corp., Sunnyvale, CA.
DEVELOPMENT AND APPLICATION OF COMPUTATIONAL AEROTHERMODYNAMICS FLOWFIELD COMPUTER CODES
Progress Report, 1 Apr. 1992 - 31 Jan. 1993
ETHIRAJ VENKATAPATHY 23 Apr. 1993 157 p

(Contract NCC2-420)
(NASA-CR-192940; NAS 1.26:192940) Avail: CASI HC A08/MF A02

Computations are presented for one-dimensional, strong shock waves that are typical of those that form in front of a reentering spacecraft. The fluid mechanics and thermochemistry are modeled using two different approaches. The first employs traditional continuum techniques in solving the Navier-Stokes equations. The second-approach employs a particle simulation technique (the direct simulation Monte Carlo method, DSMC). The thermochemical models employed in these two techniques are quite different. The present investigation presents an evaluation of thermochemical models for nitrogen under hypersonic flow conditions. Four separate cases are considered. The cases are governed, respectively, by the following: vibrational relaxation; weak dissociation; strong dissociation; and weak ionization. In near-continuum, hypersonic flow, the nonequilibrium thermochemical models employed in continuum and particle simulations produce nearly identical solutions. Further, the two approaches are evaluated successfully against available experimental data for weakly and strongly dissociating flows. Author (revised)

N93-24756 Georgia Inst. of Tech., Atlanta.
AN AEROELASTIC MODEL STRUCTURE INVESTIGATION FOR A MANNED REAL-TIME ROTORCRAFT SIMULATION Ph.D. Thesis
WILLIAM DEAN LEWIS 1992 295 p
Avail: Univ. Microfilms Order No. DA9303126

Historically, rotorcraft simulations have assumed a model structure incorporating rigid blades and uniform inflow. Advances in computational techniques and rotorcraft theory have enabled the inclusion of higher order model elements into the real-time simulation. This research addresses a model structure assessment of a flexible rotary wing manned flight simulation. The model is a UH-60 blade element simulation. The model possesses a unique capability to provide a variable model structure with consistent matching between structural and aerodynamic theory. The structural model is a representation of the flexible blade based on apriori data. The dynamic inflow model is an adaptation of the Peters and He theory. The investigation methodology consisted of a piloted assessment, frequency domain, and time domain criteria evaluations. Real-time operation permitted a piloted evaluation with rapid alterations to the model structure in question. Frequency response testing permitted an evaluation of the mid to high frequency range. The Comprehensive Identification from Frequency Response (CIFER) program was used for determining the frequency responses. Time domain response was obtained by driving the simulator controls, recording the resultant response, and comparing it to flight test data. This testing methodology was a comprehensive approach which investigated the full range of operation including objective and perceptual fidelity. The CIFER program was invaluable as a frequency response tool. Results indicated that an increase in dynamic wake complexity increased the damping of the heave, pitch and roll channels. Inclusion of blade elasticity reduced the control sensitivity and increased the excitation of existing system modes. The real-time, coupled, simultaneous solution methodology for rotorcraft modeling was superior to previous techniques for off-axis and modal predictions. The previous used model assumptions of rigid blades and uniform inflow resulted in dramatic errors in off-axis response and predictability. The inclusion of second harmonic blade dynamics and dynamic wake is essential for a simulation used in analysis, design, flight test training, and modal prediction. Dissert. Abstr.

N93-24772 Stanford Univ., CA.
COMPUTATIONAL STUDY OF THE AERODYNAMICS AND CONTROL BY BLOWING OF ASYMMETRIC VORTICAL FLOWS OVER DELTA WINGS Ph.D. Thesis
KENNETH JOHN CRAIG 1992 126 p
Avail: Univ. Microfilms Order No. DA9302194

The flowfield produced by tangential leading-edge blowing on a rounded leading-edge 60-degree delta wing is investigated computationally by solving the Thin-Layer Navier-Stokes equations. Steady-state flowfields are calculated for various angles of attack and yaw, with and without the presence of tangential leading-edge blowing. The numerical grid is generated using algebraic generation and various interpolation and blending techniques. The jet emanates from a slot with linearly-varying thickness and is introduced into the flowfield using the concept of an actuator plane, thereby not requiring resolution of the jet slot geometry. The Baldwin-Lomax algebraic turbulence model is used to provide turbulent closure. The computational results are compared with those of experiments. The effectiveness of blowing as a rolling moment control mechanism to extend the envelope of controllability is illustrated at different angles of attack. The saturation effect of increased blowing is captured well in the computations. Control reversal noted in similar experimental studies is also observed in the computations. The results are combined in a model by observing the variation of forces and moments with the parameters angle of attack, sideslip angle and blowing momentum coefficient. The model attempts to explain the physical behavior and provides a structured way to study flows of this type. Dissert. Abstr.

N93-24911*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SURFACE AND FLOW FIELD MEASUREMENTS IN A SYMMETRIC CROSSING SHOCK WAVE/TURBULENT BOUNDARY-LAYER INTERACTION
D. O. DAVIS and W. R. HINGST Jun. 1992 20 p Presented at the 10th AIAA Applied Aerodynamics Conference, Palo Alto, CA, 22-24 Jun. 1992; sponsored by AIAA Previously announced in IAA as A92-45574
(Contract RTOP 505-62-52)
(NASA-TM-106086; E-7716; NAS 1.15:106086; AIAA PAPER 92-2634) Avail: CASI HC A03/MF A01

Results of an experimental investigation of a symmetric crossing shock/turbulent boundary layer interaction are presented for a Mach number of 3.44 and deflection angles of 2, 6, 8, and 9 degrees. The interaction strengths vary from weak to strong enough to cause a large region of separated flow. Measured quantities include surface static pressure (both steady and unsteady) and flowfield Pitot pressures. Pitot profiles in the plane of symmetry through the interaction region are shown for various deflection angles. Oil flow visualization and the results of a trace gas streamline tracking technique are also presented. Author

N93-25074*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGH-ORDER CYCLO-DIFFERENCE TECHNIQUES: AN ALTERNATIVE TO FINITE DIFFERENCES
MARK H. CARPENTER and JOHN C. OTTO Mar. 1993 29 p
(Contract RTOP 505-70-62-06)
(NASA-TM-107745; NAS 1.15:107745) Avail: CASI HC A03/MF A01

The summation-by-parts energy norm is used to establish a new class of high-order finite-difference techniques referred to here as 'cyclo-difference' techniques. These techniques are constructed cyclically from stable subelements, and require no numerical boundary conditions; when coupled with the simultaneous approximation term (SAT) boundary treatment, they are time asymptotically stable for an arbitrary hyperbolic system. These techniques are similar to spectral element techniques and are ideally suited for parallel implementation, but do not require special collocation points or orthogonal basis functions. The principal focus is on methods of sixth-order formal accuracy or less; however, these methods could be extended in principle to any arbitrary order of accuracy. Author

N93-25075*# Continuum Dynamics, Inc., Princeton, NJ.
ROTOR DESIGN OPTIMIZATION USING A FREE WAKE ANALYSIS
TODD R. QUACKENBUSH, ALEXANDER H. BOSCHITSCH, DANIEL A. WACHSPRESS, and KIAT CHUA Apr. 1993 133 p
(Contract NAS2-13092; RTOP 505-59-36)
(NASA-CR-177612; A-93050; NAS 1.26:177612) Avail: CASI HC A07/MF A02

The aim of this effort was to develop a comprehensive performance optimization capability for tiltrotor and helicopter blades. The analysis incorporates the validated EHPIC (Evaluation of Hover Performance using Influence Coefficients) model of helicopter rotor aerodynamics within a general linear/quadratic programming algorithm that allows optimization using a variety of objective functions involving the performance. The resulting computer code, EHPIC/HERO (HElicopter Rotor Optimization), improves upon several features of the previous EHPIC performance model and allows optimization utilizing a wide spectrum of design variables, including twist, chord, anhedral, and sweep. The new analysis supports optimization of a variety of objective functions, including weighted measures of rotor thrust, power, and propulsive efficiency. The fundamental strength of the approach is that an efficient search for improved versions of the baseline design can be carried out while retaining the demonstrated accuracy inherent in the EHPIC free wake/vortex lattice performance analysis. Sample problems are described that demonstrate the success of this approach for several representative rotor configurations in hover and axial flight. Features that were introduced to convert earlier demonstration versions of this analysis into a generally applicable tool for researchers and designers is also discussed.
Author (revised)

N93-25083*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
A CONTRIBUTION TO THE GREAT RIEMANN SOLVER DEBATE
JAMES J. QUIRK Washington Nov. 1992 34 p Submitted for publication to the International Journal for Numerical Methods in Fluids
(Contract NAS1-18605; NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-191409; NAS 1.26:191409; ICASE-92-64; AD-A2599994) Avail: CASI HC A03/MF A01

The aims of this paper are threefold: to increase the level of awareness within the shock capturing community to the fact that many Godunov-type methods contain subtle flaws that can cause spurious solutions to be computed; to identify one mechanism that might thwart attempts to produce very high resolution simulations; and to proffer a simple strategy for overcoming the specific failings of individual Riemann solvers. Author

N93-25091*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLIED AERODYNAMICS: CHALLENGES AND EXPECTATIONS
VICTOR L. PETERSON and CHARLES A. SMITH Feb. 1993 20 p Presented at the AIAA 10th Applied Aerodynamics Conference, Palo Alto, CA, 22-24 Jun. 1992 Original contains color illustrations
(Contract RTOP 505-90-00)
(NASA-TM-103963; A-92160; NAS 1.15:103963) Avail: CASI HC A03/MF A01; 1 functional color page

Aerospace is the leading positive contributor to this country's balance of trade, derived largely from the sale of U.S. commercial aircraft around the world. This powerfully favorable economic situation is being threatened in two ways: (1) the U.S. portion of the commercial transport market is decreasing, even though the worldwide market is projected to increase substantially; and (2) expenditures are decreasing for military aircraft, which often serve as proving grounds for advanced aircraft technology. To retain a major share of the world market for commercial aircraft and continue to provide military aircraft with unsurpassed performance, the U.S. aerospace industry faces many technological challenges. The field of applied aerodynamics is necessarily a major contributor to efforts aimed at meeting these technological challenges. A number of emerging research results that will provide new opportunities for applied aerodynamicists are discussed. Some of these have great potential for maintaining the high value of contributions from applied aerodynamics in the relatively near future. Over time, however, the value of these contributions will diminish greatly unless substantial investments continue to be made in basic and applied research efforts. The focus: to increase understanding of fluid dynamic phenomena, identify new aerodynamic concepts, and provide validated advanced technology for future aircraft. Author (revised)

N93-25117*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
GRID SENSITIVITY FOR AERODYNAMIC OPTIMIZATION AND FLOW ANALYSIS Progress report, period ending Dec. 1992
I. SADREHAGHIGHI and S. N. TIWARI Apr. 1993 120 p
(Contract NCC1-68)
(NASA-CR-192980; NAS 1.26:192980) Avail: CASI HC A06/MF A02

After reviewing relevant literature, it is apparent that one aspect of aerodynamic sensitivity analysis, namely grid sensitivity, has not been investigated extensively. The grid sensitivity algorithms in most of these studies are based on structural design models. Such models, although sufficient for preliminary or conceptional design, are not acceptable for detailed design analysis. Careless grid sensitivity evaluations, would introduce gradient errors within the sensitivity module, therefore, infecting the overall optimization process. Development of an efficient and reliable grid sensitivity module with special emphasis on aerodynamic applications appear essential. The organization of this study is as follows. The physical and geometric representations of a typical model are derived in chapter 2. The grid generation algorithm and boundary grid distribution are developed in chapter 3. Chapter 4 discusses the theoretical formulation and aerodynamic sensitivity equation. The method of solution is provided in chapter 5. The results are presented and discussed in chapter 6. Finally, some concluding remarks are provided in chapter 7. Author

N93-25121# Sandia National Labs., Albuquerque, NM.
A SIMPLE, APPROXIMATE MODEL OF PARACHUTE INFLATION
J. M. MACHA 1992 10 p Presented at the 12th Royal Aeronautical Society/American Institute of Aeronautics and Astronautics (RAS/AIAA) Aerodynamic Decelerator Systems Technical Conference, London, England, 10 May 1993
(Contract DE-AC04-76DP-00789)
(DE93-002465; SAND-92-2282C; CONF-930580-1) Avail: CASI HC A02/MF A01

A simple approximate model of parachute inflation is described. The model is based on the traditional, practical treatment of the fluid resistance of rigid bodies in nonsteady flow, with appropriate extensions to accommodate the change in canopy inflated shape. Correlations for the steady drag and steady radial force as functions of the inflated radius are required as input to the dynamic model. In this approach, the radial force is expressed in terms of easily obtainable drag and reefing fine tension measurements. A series of wind tunnel experiments provides the needed correlations. Coefficients associated with the added mass of fluid are evaluated by calibrating the model against an extensive and reliable set of flight data. A parameter is introduced which appears to universally govern the strong dependence of the axial added mass coefficient on motion history. Through comparisons with flight data, the model is shown to realistically predict inflation forces for ribbon and ringslot canopies over a wide range of sizes and deployment conditions.
DOE

N93-25153*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
INSTABILITY OF FLOW IN A STREAMWISE CORNER Final Report
MANHAR R. DHANAK (Florida Atlantic Univ., Boca Raton.) Washington Dec. 1992 18 p Submitted for publication
Sponsored by NASA. Langley Research Center
(Contract NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-191410; NAS 1.26:191410; ICASE-92-70) Avail: CASI HC A03/MF A01

The linear stability of an incompressible laminar flow in the blending boundary layer between the boundary layer in a 90 deg streamwise corner and a Blasius boundary layer well away from the corner is examined using a locally parallel flow approximation.

It is shown that the influence of the outer boundary conditions associated with oblique modes of disturbances which are anti-symmetric about the bisector plane have a profound effect on the stability of the flow. As a result, in good agreement with observation, the critical streamwise Reynolds number, associated with a spanwise location is significantly reduced as the corner is approached, being R(sub Cr) = 60 approximately for spanwise distance of z* = 6x*R(sup -1) from the corner compared with R(sub Cr) = 322 approximately for z* = 20x*R(sup -1), where x* measures downstream distance from the leading edges. At R = 600, the growth rate of the most amplified mode of disturbance at the former location is over six times greater than that at the latter; the corresponding wave angle at the two locations is respectively 44 deg and 5 deg, approximately. Author (revised)

N93-25249*# Pennsylvania State Univ., University Park. Gas Dynamics Lab.
SUPERSONIC SHOCK WAVE/VORTEX INTERACTION Final Technical Report, 1 Apr. 1989 - 30 Sep. 1992
G. S. SETTLES and L. CATTAFESTA Apr. 1993 43 p
(Contract NAG2-575)
(NASA-CR-192917; NAS 1.26:192917) Avail: CASI HC A03/MF A01

Although shock wave/vortex interaction is a basic and important fluid dynamics problem, very little research has been conducted on this topic. Therefore, a detailed experimental study of the interaction between a supersonic streamwise turbulent vortex and a shock wave was carried out at the Penn State Gas Dynamics Laboratory. A vortex is produced by replaceable swirl vanes located upstream of the throat of various converging-diverging nozzles. The supersonic vortex is then injected into either a coflowing supersonic stream or ambient air. The structure of the isolated vortex is investigated in a supersonic wind tunnel using miniature, fast-response, five-hole and total temperature probes and in a free jet using laser Doppler velocimetry. The cases tested have unit Reynolds numbers in excess of 25 million per meter, axial Mach numbers ranging from 2.5 to 4.0, and peak tangential Mach numbers from 0 (i.e., a pure jet) to about 0.7. The results show that the typical supersonic wake-like vortex consists of a non-isentropic, rotational core, where the reduced circulation distribution is self similar, and an outer isentropic, irrotational region. The vortex core is also a region of significant turbulent fluctuations. Radial profiles of turbulent kinetic energy and axial-tangential Reynolds stress are presented. The interactions between the vortex and both oblique and normal shock waves are investigated using nonintrusive optical diagnostics (i.e. schlieren, planar laser scattering, and laser Doppler velocimetry). Of the various types, two Mach 2.5 overexpanded-nozzle Mach disc interactions are examined in detail. Below a certain vortex strength, a 'weak' interaction exists in which the normal shock is perturbed locally into an unsteady 'bubble' shock near the vortex axis, but vortex breakdown (i.e., a stagnation point) does not occur. For stronger vortices, a random unsteady 'strong' interaction results that causes vortex breakdown. The vortex core reforms downstream of the rear stagnation point, and the reduced circulation distribution once again becomes self-similar in this region. A new model of this interaction is proposed. Finally, a curve defining the approximate limits of supersonic vortex breakdown is presented.
Author (revised)

N93-25269 Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE TRANSIENT DEVELOPMENT OF VORTICES OVER DELTA WINGS Ph.D. Thesis
OTHON KONS REDINIOTIS 1992 359 p
Avail: Univ. Microfilms Order No. DA9304624

An experimental investigation was carried out on the flow over a 75 deg-sweep delta wing. The flowfield over a stationary delta wing at high angles of attack was studied, particularly focusing on breakdown behavior and natural unsteadiness. Static surface pressure measurements on the leeward side of the model were obtained for different Reynolds numbers and angles of attack. Detailed velocity fields, mapped out by a seven-hole probe and two different laser-Doppler velocimetry (LDV) systems, were studied to provide information on the structure of the leading-edge vortices. Comparisons were made of the results obtained using intrusive and non-intrusive techniques. Through surface pressure and velocity power spectra, organized periodic activity in the broken down vortex was detected and studied. The flowfield over a delta wing performing dynamic pitch-up motions was also investigated. Unsteady surface pressures were measured and compared with the steady case pressure distributions. The unsteady velocity field on different planes was mapped out using a specially manufactured and calibrated fast-response seven-hole probe as well as a 3-D and a 3-D laser-Doppler velocimeter. The transient development of the leading-edge vortices in terms of velocity and vorticity distribution was carefully studied. The flowfield in the wake of the delta wing was also examined at angles of attack as high as alpha = 90 deg, using hot-wire anemometry and flow visualization. Periodic vortex shedding was detected and its characteristics, such as Strouhal number variation and modes of shedding, were studied. Dissert. Abstr.

N93-25274 Colorado Univ., Boulder.
AERODYNAMIC FOUNDATIONS FOR USE OF UNSTEADY AERODYNAMIC EFFECTS IN FLIGHT CONTROL Ph.D. Thesis
THOMAS EUGENE MCLAUGHLIN 1992 177 p
Avail: Univ. Microfilms Order No. DA9304582

Unsteady aerodynamic effects have long been postulated as a means to enhance low speed performance of aircraft. Lift coefficients as high as four to five times greater than the steady state values are possible. However, before the phenomenon can be exploited, the temporal nature of these forces must be quantified and predicted over the widest possible range of forcing conditions. Unsteady aerodynamic force generation collected from numerous experimental efforts was examined over a wide range of non-dimensional pitch rates, Reynolds numbers, mach numbers, and sinusoidal and constant rate motion histories. Airfoils tested included those of varying camber and with two- and three-dimensional geometries. Unsteady aerodynamic forces were found to change linearly with non-dimensional time. The duration of the unsteady event was found to be a function only of non-dimensional pitch rate or frequency, and of the initial state of the airfoil. Force magnitudes generated at any given time in the event were found to depend simply on the same parameters and on airfoil static characteristics. Sinusoidal and constant rate pitch motions were found to produce very similar force histories. Increasing airfoil sweep improved the duration of the unsteady event. In all cases, the unsteady forces produced were found highly predictable and well-correlated across the range of forcing parameters. These findings offer a basis on which flight control algorithms may be developed to increase aircraft low speed turn performance. Dissert. Abstr.

N93-25339 Minnesota Univ., Minneapolis.
A NUMERICAL AND EXPERIMENTAL STUDIES OF FLOW CHARACTERISTICS IN CENTRIFUGAL FANS Ph.D. Thesis
LINXI XIA 1992 282 p
Avail: Univ. Microfilms Order No. DA9234032

Flow characteristics, performances, and noises of centrifugal fans were studied. The work can be grouped as: (1) experimentally examining the flow structure downstream of the impeller and its relationship with noise characteristics; (2) numerically simulating the flow field in impeller and fan housings, and establishing their aerodynamic design criteria; and (3) exploring new and more accurate sound rating and low-frequency fluctuation simulation methods. The objective is to increase understanding of fan aerodynamic noise generation mechanism, to advance engineering analysis and design tools, and to improve the efficiency and acoustic performances of the current centrifugal fans. The test results showed that the fan components designed with the proposed aerodynamic design method have 5 percent efficiency improvement and 3-15 dB noise reduction over the current designs. Also, the design effectiveness was increased significantly compared with the traditional fan design methods. Dissert. Abstr.

N93-25388 Arizona State Univ., Tempe.
NUMERICAL SIMULATION OF LEADING-EDGE RECEPTIVITY TO FREESTREAM VORTICITY Ph.D. Thesis
THOMAS ALAN BUTER 1992 199 p
Avail: Univ. Microfilms Order No. DA9237239

The receptivity to freestream vorticity of the boundary layer over a flat plate with an elliptic leading edge is investigated numerically. The flow is simulated by solving the incompressible Navier-Stokes system in general curvilinear coordinates with the vorticity and stream function as dependent variables. A finite-difference scheme which is second-order accurate in both space and time is used. As a first step, the steady basic-state solution is computed. Then a small-amplitude vortical disturbance is introduced at the upstream boundary and the governing equations solved time accurately to evaluate the spatial and temporal growth of the perturbations leading to instability waves (Tollmien-Schlichting waves) in the boundary layer. Disturbance amplitude, orientation, the effect of the leading edge and of juncture curvature are investigated for the case of spanwise vorticity. Simulations reveal, for the conditions considered, a linear variation in the TS response with forcing amplitude for a perturbation of the freestream velocity which is either symmetrical or asymmetrical with respect to the basic-state stagnation streamline. The presence of a large transverse component of velocity along the basic-state stagnation streamline for the case of an asymmetrical perturbation of velocity results in the appearance of a superharmonic component near the nose. This superharmonic decays rapidly along the nose for the flow conditions considered. In all cases considered, the first clear appearance of the TS mode occurs aft of the surface pressure-gradient maximum in the juncture region. Changes to the geometry which increase the maximum the basic-state pressure gradient near the juncture are found to increase receptivity.
Dissert. Abstr.

N93-25409 Colorado Univ., Boulder.
COMPUTATION OF TRANSONIC FLOW OVER A POROUS SURFACE PROJECTILE Ph.D. Thesis
JIH-LAN HSIUNG 1992 144 p
Avail: Univ. Microfilms Order No. DA9304565

A numerical tool is constructed to predict the aerodynamic performance of a projectile, and to examine the effects of making a part of the projectile surface porous on its performance in the transonic regime, 0.9 less than M less than 1.2. The code developed in this study, POROUS, includes the Darcy's law describing the flow through a porous surface and a turbulence model taking the transpiration effect into consideration. The computed results for transonic flow over a solid secant-ogive-cylinder-boattail (SOCBT) projectile show good agreements with experimental data in both pressure coefficient distribution and shock wave location. For the Mach numbers and angles of attack that have been examined so far for the solid SOCBT, the surface pressure predicted by our POROUS code is found to be more accurate than those by other numerical and semi-empirical codes. The passive control technique by using porous surface to reduce the total drag of a projectile has been investigated here for Mach numbers from 0.90 to 1.2 and angles of attack 0 to 4 degrees. The porous surface works very well in drag reduction at subsonic Mach numbers 0.94-0.98 when there are strong shocks on the boattail. At Mach 0.96, a total drag reduction as high as 28.43 percent has been achieved with properly selected porous surfaces. With an angle of attack, the efficiency of drag reduction can be improved if splitters are placed in the cavity, and the lift may also be increased. According to the present analysis, having porous surfaces of uniform porosity on both cylinder and boattail is found to be the most efficient arrangement. The total drag decreases with increasing maximum porosity factor, whose limiting value has been determined. The porosity is more effective if the original shock on the solid projectile is near the rear of the porous region on the cylinder; otherwise, efficiency increases with the length of the porous surface. Dissert. Abstr.

N93-25467 Oxford Univ. (England).
AN EXPERIMENTAL STUDY OF UNDER-EXPANDED JETS Ph.D. Thesis
TERRENCE M. CAIN 1991 156 p
Avail: Univ. Microfilms Order No. BRD-98281

Experiments were conducted on turbulent under-expanded jets of nitrogen and carbon dioxide exhausted into still air from Mach 3 and Mach 5 conical nozzles. The ratio of the stagnation pressure in the nozzle to the static pressure in the receiving tank was of the order 10(exp 3) which is a condition representative of rocket exhaust plumes generated at altitudes near 20 km. The Oxford gun tunnel was adapted for the project by attaching a small nozzle to its barrel. Jets were generated in the tunnel's test section, photographed with a schlieren system and traversed by a Pitot probe. The traverse mechanisms developed for this work allow 100 mm travel during the period of 20 ms over which the tunnel stagnation pressure is constant. Methods of increasing this steady period (the test time) by modification of the tunnel's driver tube are suggested after a detailed investigation of the tunnel's operation. Pitot pressure surveys which reveal the plume structure and provide information about the turbulent mixing downstream of the first shock cell are presented. The measurements in plumes at various pressure ratios are correlated by normalizing the probe position with the size of the first shock cell and normalizing the Pitot pressure by the pressure in the receiver. The characteristics of under-expanded jets are summarized and available experimental data is reviewed and classified using recently published plume similarity parameters. The asymmetrical nature of plumes is discussed and a physical explanation for plume shock layer instability is given. Condensation of the plume gas is investigated by reference to previous experiments and theoretical models. It is shown that it is unlikely that condensation occurred anywhere within the nitrogen plumes as drop growth rates are negligible at high entropy. Method of characteristics (MOC) calculations of the initial plume expansion were compared with the Pitot measurements in the plume core. Variation of the nozzle exit conditions used for the boundary conditions of the MOC predictions is used to demonstrate that viscous and two-dimensional effects within the nozzle were not very significant. Dissert. Abstr.

N93-25487# Virginia Polytechnic Inst. and State Univ., Blacksburg.
EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF HELIUM INJECTION INTO AIR AT SUPERSONIC AND HYPERSONIC SPEEDS Ph.D. Thesis
ERIC JAMES FULLER 1992 187 p
Avail: Univ. Microfilms Order No. DA9233626

Experiments were performed to determine the mixing rate and core penetration of the injectant and the flow field total pressure losses when gaseous injection occurs into a supersonic freestream. Tested in a freestream Mach number of 3.0 and a freestream Reynolds number of 5.0 x 10(exp 7)/m, was a single, sonic 5x underexpanded helium jet with a transverse angle of 30 degrees, and rotated from 0 to -28 degrees to test injector yaw effects. Tested at Mach 6.0 with a freestream Reynolds number of 5.4 x 10(exp 7)/m, was an array of three supersonic, 5x underexpanded helium injectors with an exit Mach number of 1.7 and a transverse angle of 15 degrees. This injector array was tested at yaw angles of 0 and -15 degrees. Surface flow visualization showed that significant flow asymmetries were produced by injector yaw. Nanosecond exposure shadowgraph pictures showed the injection plume to be unsteady, and further studies demonstrated this unsteadiness to be related to observed shock waves orthogonal to the injectant bow shock, generated at a frequency of 30 kHz. The primary data technique was a concentration probe which measured the flow field molar concentration of helium. Concentration and meanflow data were taken at several downstream stations and yielded contours of helium concentration, total pressure, Mach number, as well as other flow field properties. The injectant mixing rates, expressed as the maximum concentration decay rates, and mixing distances were found to be unaffected by injector yaw, in the Mach 3.0 experiments, but adversely affected by injector yaw in the Mach

6.0 experiments. One promising aspect of injector yaw was that as the yaw angle was increased, lateral motion of the injectant plume became significant, and the turbulent mixing region increased by approximately 34 percent. Comparisons of the 15 degree injection into a Mach 6.0 flow to previous experiments with 15 degree injection into a Mach 3.0 freestream, demonstrated that there was a significant decrease in initial mixing, at Mach 6.0, resulting in a much longer mixing distance. From a parametric computational study of the Mach 6.0 experiments, the effects of adjacent injectors was found to decrease lateral spreading while increasing the vertical penetration of the injectant plume, and marginally increasing the injectant core decay rate.

Dissert. Abstr.

N93-25542 Stanford Univ., CA.
NAVIER-STOKES SIMULATIONS OF UNSTEADY TRANSONIC FLOW PHENOMENA Ph.D. Thesis
CHRISTOPHER ALEXANDE ATWOOD 1992 131 p
Avail: Univ. Microfilms Order No. DA9234053

Numerical simulation of two classes of unsteady flows are obtained via the Navier-Stokes equation: a blast-wave/target interaction problem class and a transonic cavity flow problem class. The method developed for the viscous blast-wave/target interaction problem assumes a laminar, perfect gas implemented in a structured finite-volume framework. The approximately factored implicit scheme uses Newton subiterations to obtain the spatially and temporally second-order accurate time history of the interaction of blast-waves with stationary targets. The inviscid flux is evaluated using either of two upwind techniques, while the full viscous terms are computed by central differencing. Comparisons of unsteady numerical, analytical, and experimental results are made in two- and three-dimensions for Couette flows, a starting shock-tunnel, and a shock-tube blocking study. The results show accurate wave speed resolution and nonoscillatory discontinuity capturing of the predominantly inviscid flows. Viscous effects were increasingly significant at large post-interaction times. While the blast-wave/target interaction problem benefits from high resolution methods applied to the Euler terms, the transonic cavity flow problem requires the use of an efficient scheme implemented in a geometrically flexible overset mesh environment. Hence, the Reynolds averaged Navier-Stokes equations implemented in a diagonal form are applied to the cavity flow class of problems. Comparisons between numerical and experimental results are made in two-dimensions for free shear layers and both rectangular and quieted cavities, and in three-dimensions for Stratospheric Observatory For Infrared Astronomy (SOFIA) geometries. The acoustic behavior of the rectangular and three-dimensional cavity flows compare well with experiment in terms of frequency, magnitude, and quieting trends. However, there is a more rapid decrease in computed acoustic energy with frequency than observed experimentally owing to numerical dissipation. In addition, optical phase distortion due to the time-varying density field is modelled using geometrical constructs. The computed optical distortion trends compare with the experimentally inferred result, but underpredicts the fluctuating phase difference magnitude.

Dissert. Abstr.

N93-25545 Stanford Univ., CA.
TANGENTIAL FUSELAGE BLOWING ON AN OGIVE CYLINDER Ph.D. Thesis
GABRIEL IVAN FONT 1992 193 p
Avail: Univ. Microfilms Order No. DA9234095

The nose vortices of aircraft or missiles tend to become asymmetric at high angles of attack producing a side force which is destabilizing to the body. A jet located near the nose and blown tangentially to the fuselage has the ability to alter the flow field and diminish the unwanted side force. Alternatively, it can produce a large side force which can be used for improving the maneuverability of the vehicle. This work explores the effects of tangential blowing on the vortical structures that develop about the fuselage of a missile or aircraft at a high angle of attack. A tangent-ogive cylinder configuration was used to allow comparison with experiments. The study was carried out numerically by solving the Thin-Layer, Reynolds-Averaged, compressible Navier-Stokes equations. A zonal method was used to solve the equations. The jet was implemented with an actuator plane. Computations were conducted in a fully laminar and a fully turbulent manner. Appropriate algebraic turbulence models were used for the jet and the boundary layers in the turbulent computations. The study was conducted at a Reynolds number, based on diameter, of 52000, and Mach number of 0.2. The angles of attack used were 10, 30 and 45 deg. The influence of slot location were also explored. This study confirmed that large side forces could be generated from tangential blowing even at low angles of attack. Several conclusions were made concerning the physical mechanisms by which the jet interacts with the ambient flow field to produce a side force: (1) A pressure gradient normal to the surface is created near the wall due to the momentum of the jet being forced to follow the curvature of the surface. (2) A large amount of vorticity is added to the flow field by the jet. In the region of the slot, the vorticity has the effect of inducing circulation around the body. Downstream of the slot, the vorticity alters the strength of the nose vortices. And (3), the position of the nose vortices can be altered by the actions of the jet. Dissert. Abstr.

N93-25664 Georgia Inst. of Tech., Atlanta.
AN INVESTIGATION ON PLANAR VELOCIMETRY BY SPATIAL CROSS-CORRELATION Ph.D. Thesis
PHILIP ANDREW FAWCETT 1992 213 p
Avail: Univ. Microfilms Order No. DA9303118

Advances in rotorcraft aerodynamics require the ability to measure instantaneous velocity fields with high temporal resolution over large areas. Existing measurement techniques are not adequate for such flows. This thesis explores planar velocimetry by spatial cross correlation. The spatial cross correlation is determined between two flowfield images separated by a known time delay. Unlike existing particle image velocimetry (PIV) techniques, there is no need to resolve individual particles. Instead, patterns of scattered light intensity are used to determine statistical correlations. With this process, the time required to measure velocity fields is vastly reduced. The post-processing is reduced to a completely computational procedure which takes advantage of the rapid advances in computer technology. This technique is seen to be a superset of PIV and laser speckle techniques. Numerical simulations were used to prove that the technique gives correct results with deterministic and random data, and it performs accurately despite the presence of high levels of noise. Initial experimental validation was performed using a moving solid surface with a random, fine grained pattern. The technique was next extended to the measurement of steady and unsteady flows in a water table with a standard video camera and ambient lighting. Low-speed and then high-speed air flows were measured using light sources ranging from a high-powered, pulsed, copper vapor laser to a 9 volt flashlight. A variety of imaging and computer equipment investigated during the development of SCV is described in the thesis along with the chronology of the experiments. The final form of the system is described in detail and consists of a dual camera imaging system coupled with an MS-DOS based computer and video digitizing board. Three advanced applications were used successfully to study the capabilities of the technique. The first was the flow around a wing of high aspect ratio executing plunging motion of large amplitude and high-rate in a wind tunnel. The second was the quantification of the time history of velocity around a canard-wing configuration during continuous changes in canard position. The final application was the study of the highly three dimensional unsteady wake of a rotor in forward flight. Iterative computational algorithms for enhancing the statistical accuracy and spatial resolution are described. Dissert. Abstr.

N93-25706 Stanford Univ., CA.
ANALYSIS OF WING WAKE ROLL-UP USING A VORTEX-IN-CELL METHOD Ph.D. Thesis
RENATO SILVA RIBEIRO 1992 213 p
Avail: Univ. Microfilms Order No. Da9234153

A wing producing lift generates a thin vorticity sheet behind it, called a vortex wake. This wake is convected downstream, adjusting

its shape in order to remain force-free, and can interact with other surfaces and wakes as it does so. The determination of wake geometries and effects are of great interest in several aircraft design problems, including analysis of canard-wing interference, rotors and propeller-wing interference. This work applies a vortex-in-cell method to a singularity model for wings and wakes in steady, incompressible flow. Wings are represented by a vortex-lattice model, while wakes are formed by line vortices. The vorticity contained in the singularities is spread onto a rectangular grid, using quadratic splines based on the grid-cell dimensions. Velocities are computed from the vorticity field by an infinite boundary Fast Poisson Solver, which employs fast Sine and Cosine transforms and a boundary convolution scheme. Although the grid boundaries are placed close to the singularities, the solution is consistent with the condition of vanishing perturbations at infinity. Provisions are made to take into account portions of the wakes downstream of the grid box. Velocities at points inside the grid are obtained by interpolation. The result is the removal of infinite velocities, as if a infinite vortex-core model were introduced. The velocities computed with the vortex-in-cell method are used to relax the wake and to correct the singularity strengths on the wing, in a mixed iterative procedure. Several problems are studied to evaluate the performance of the method: velocity induced by single infinite and semi-infinite vortices, lift of rectangular and swept-back wings, roll-up of single wing wakes and interaction between wings and wakes in various arrangements. Solutions for these problems were compared with results from experiments and other methods. Detailed descriptions for wake geometry and accurate load distributions were obtained, even for cases where wakes intercepted wings directly. The method provides velocity values throughout the grid as part of the solution. The computational time required is controlled by the number of grid cells, not the number of singularities. Dissert. Abstr.

N93-25720 Stanford Univ., CA.
AN INVESTIGATION OF PHOTOTHERMAL VELOCIMETRY FOR APPLICATION TO TRANSIENT, HIGH-SPEED GAS FLOWS Ph.D. Thesis
THEODORE PHILIP DELIANIDES 1992 144 p
Avail. Univ. Microfilms Order No. DA9234084

The measurement of velocity is fundamental to the study of fluid mechanics. Though much can be learned from flow visualization, a better understanding of a flow phenomenon requires the measurement of velocity and thermodynamic properties. In the modern gas-dynamics laboratory, bulky physical probes such as hot-wire anemometers and pitot tubes that were for many years the only means of measuring velocity have been supplemented by optical diagnostic techniques which are nonintrusive, have high spatial and temporal resolutions, and are capable of rapid data acquisition rates. From a flow-diagnostician's viewpoint, perhaps the most challenging flows are transient ones, that is, those exhibiting large-scale flow-structure variations with time. Unfortunately, the existing optical diagnostic techniques for velocity measurement are not well-suited for studying high-speed, transient flows. They are either too intrusive by nature or limited in their applicability because the various optical phenomena on which they are based are adversely affected by flow conditions. A new and potentially powerful velocimetry technique has been developed that is based on the heating that accompanies intermolecular quenching collisions. It uses a pulsed laser tuned to an absorption band of a seed species to create a thermally-tagged line in a flow. The line is tracked spatially and temporally using a refractive-index-sensitive imaging system. In the current work, thermal tags are created with a pulsed carbon dioxide laser in flows of nitrogen gas seeded with a small fraction of sulfur hexafluoride and are tracked either with a schlieren or shadowgraph imaging system. An initial investigation of the quasi-steady flow from an axisymmetric nozzle yield velocity measurements that compare well to pitot tube measurements at the same positions. The flow induced by a propagating normal shock wave is also studied, and measurements are reported of the velocity directly behind a shock wave as it exits a shock tube. The first application of the new technique is to the study of a 100 percent-duty-cycle-pulsed, high-speed axisymmetric jet. Axial velocity profiles at various times and spatial positions are presented, with peak velocities exceeding 300m/sec. For a mechanically-valve-actuated pulse jet, this is the highest output flow velocity ever investigated. Dissert. Abstr.

N93-25752 Houston Univ., TX.
INITIAL STREAMWISE VORTICITY FORMATION IN A TWO-STREAM MIXING LAYER Ph.D. Thesis
CHAO-HUNG STEVE TUNG 1992 240 p
Avail. Univ. Microfilms Order No. DA9235931

The formation and evolution of streamwise vortices in a two-stream mixing layer were experimentally investigated. The formation and pairing of the spanwise coherent structures were stabilized by acoustic excitation so that they occurred at fixed streamwise locations. The forcing signal consisted of two frequency components: the initial instability frequency and its first subharmonic. The latter also served as the triggering signal and phase reference for A/D sampling. No artificial spanwise forcing was applied but small disturbances originating from the splitter plate were allowed to develop with the mixing layer. Time traces of three velocity components on a two-dimensional grid of locations were recorded by hot-wire anemometry with an x-wire probe at successive streamwise stations. From these, three-dimensional distributions of ensemble-average spanwise and streamwise vorticities were computed and analyzed. The spanwise coherent structures remained quasi-two-dimensional from the initial roll-up to the end of the first structure amalgamation. During this process, the structure spacing changed from the initial instability wavelength to the first subharmonic wavelength. Concentrated streamwise vortices were first observed at the start of the first spanwise structure pairing. They appeared on the peripheries and between the amalgamating spanwise structures at isolated spanwise locations. Downstream, additional vortices were generated at spanwise locations adjacent to the original vortices, which remained at the same spanwise locations. These structures formed counter-rotating pairs located alternately along the spanwise direction. Their three-dimensional vorticity distributions agree with the interwinding-vortex-line model previously proposed by others. The upstream spacing between streamwise vortices of the same sign was about 2/3 of the initial instability wavelength of the spanwise structures. Near the end of the spanwise structure amalgamation, pairing between streamwise vortices of the same sign occurred. However, this phenomenon did not take place uniformly over the entire span of measurement. As a result, global doubling in spanwise wavelength did not occur when the streamwise wavelength doubled. Turbulent bursts were first observed in the regions occupied by the spanwise structures near the completion of the first amalgamation. Results from the present study were inconclusive in relating these bursts to the presence of streamwise structures in those regions. Dissert. Abstr.

N93-25759 North Carolina State Univ., Raleigh.
A NEW LU-SGS FLOW SOLVER FOR CALCULATING REENTRY FLOWS Ph.D. Thesis
DAVID RAMOS OLYNICK 1992 192 p
Avail: Univ. Microfilms Order No. DA9303674

An LU-SGS flow solver is developed and evaluated. The LU-SGS method of Yoon is adapted to calculate axisymmetric, chemically reacting, and weakly ionized flowfields characteristic of reentry vehicles. Modifications are presented that improve the numerical efficiency and stability of the LU-SGS scheme for the calculation of nonequilibrium reacting flows. A parallel effort is made to improve the physical modeling of the flowfield. A new two-temperature dissociation model is derived from kinetic theory to account for the coupled vibration-dissociation process. The model minimizes uncertainties associated with the Park two-temperature model. The effects of the model on AOTV type flowfields are examined. The accuracy of the continuum equations employed are examined by comparing with numerical flow solutions generated using the Direct Simulation Monte Carlo (DSMC) method. For this comparison, a four temperature thermal model is employed that allows the calculation of separate translational, rotational, vibrational, and electron-electronic temperatures. Calculations were

made for flows with and without ionization over the Project Fire 2 vehicle. For the Project Fire 2 conditions considered (76 km and above), assuming the translational temperature equal to rotational temperature and the vibrational temperature equal to the electron-electronic temperature were found to be poor approximations. Surface convective heat transfer for a number of Fire 2 flow calculations are compared. The trends of the Fire 2 experimental data were predicted and the present numerical results compared well with solutions from other Computational Fluid Dynamic (CFD) codes and the DSMC method. The effects of a number of flow phenomena on the convective surface heating are examined. For the Fire 2 conditions considered, the flow was almost fully dissociated. As a result, the recombination of nitrogen was found to have the most influence on the surface heating rates. Other phenomena such as changing the thermal model, transport model, number of species, and chemical rates had little effect on the surface convective heat transfer rates. Finally, the computational efficiency of the present method is compared to the Gauss-Siedel line relaxation method of Candler. CPU costs for each method are calculated for inviscid and viscous flows in thermal and chemical nonequilibrium over a cylinder. Total CPU costs for the methods were found to be comparable for the inviscid calculation. However, the Gauss-Siedel method was found to be much faster than the present LU-SGS scheme for viscous flow calculations. Dissert. Abstr.

N93-25865 Arizona State Univ., Tempe.
STATIONARY CROSSFLOW INSTABILITY ON AN INFINITE SWEPT WING Ph.D. Thesis
RAY-SING LIN 1992 220 p
Avail: Univ. Microfilms Order No. DA9237268

The Swept Laminar Flow Wing has long been a goal for aerodynamic scientists and engineers. Here the ideas of Laminar Flow Control (LFC) are applied to delay transition and maintain laminar flow over a much larger fraction of a wing surface. When applied to a swept wing, a configuration adopted by current-generation civil-transport aircraft, a significant reduction in drag and substantial increase in energy efficiency could result. To successfully apply this technology, a thorough knowledge and understanding of the transition process on the swept wing is necessary. Because the boundary-layer flow over a swept wing is highly three-dimensional (3-D), streamwise co-rotating crossflow vortices exist, which strongly affect the transition of laminar flow to turbulent. In this work, the stability of the flow over a 70 degree swept, infinite-span wing is examined both by quasi-parallel linear stability theory and by numerically solving the 3-D unsteady incompressible Navier-Stokes (N-S) equations in primitive-variable form. Near the leading edge, steady blowing and suction of chosen wavelength in the spanwise direction is introduced on the wall surface to simulate surface irregularity and generate an instability. The linear stability problems are solved by a Chebyshev-collocation method, while the 3-D full N-S simulation is accomplished by a Fourier-spectral/finite-difference/multiple-grid scheme (developed by the author), which is shown to be accurate and robust. Results of the linear stability analysis indicate that the convex wall curvature has a stabilizing effect while the streamline curvature has a destabilizing effect on the stationary crossflow vortices. The results of direct N-S simulation support the so-called crossflow/crossflow structure which is a consequence of nonlinear interaction near the wall. Strong spanwise modulation of the streamwise-velocity profiles results in the appearance of multiple inflection points. A detailed comparison of the N-S calculation with linear theory and experimental results is provided. Dissert. Abstr.

N93-25881 Purdue Univ., West Lafayette, IN.
SIMULATION OF VORTEX BURSTING Ph.D. Thesis
JIAK-KWANG TAN 1992 164 p
Avail: Univ. Microfilms Order No. DA9301391

The 3-D, incompressible, time-dependent Navier-Stokes equations in primitive variables are used to simulate bursting of a line vortex embedded in a unbounded uniform flow. The entire study is divided into three parts. First, the steady axisymmetric vortex behavior with various swirl level is studied. At low swirl level, the vortex flow remains parallel and can be described by the quasi parallel equations. At higher swirl levels, the flow develops large amplitude waves. When the amplitude of these waves is large enough, recirculation bubbles will occur on the vortex axis. The flow within the recirculation bubbles is found to nearly obey the Prandtl-Batchelor's conditions. Secondly, the spatial and temporal evolution of axisymmetric vortex breakdown is investigated. When the swirl and Reynolds number are small, asymptotically steady flows develop, with steady recirculation bubbles at the higher swirl. When the swirl and Reynolds number are high enough, ring vortices are shed periodically from the primary (mostly steady) bubble, much as would happen from a bluff body. A steady/unsteady boundary dividing asymptotically steady and unsteady flow is constructed in the swirl parameter vs Reynolds number plane. It appears that the high Reynolds number limit of the boundary is at the swirl level corresponding to Benjamin's vortex criticality condition. As Reynolds number decreases, the swirl level required to induce unsteady flow increases. The Strouhal number of the shed vortices is about .2, independent to both the swirl parameter and Reynolds number. Lastly, 3-D stability of the steady and unsteady axisymmetric flows at some selected swirl parameter and at a constant Reynolds number, is examined. A small, but finite, first harmonic perturbation is introduced and the behavior of the flow is simulated by solving the full 3-D Navier-Stokes equations. At low swirl level, where quasi parallel is valid, the flow is found to be stable to 3-D perturbations. At higher swirl, where the quasi parallel approximation fails and the axisymmetric flow is wavy but has no bubble, the flow evolves into a spiral type of vortex breakdown. At even higher swirl, where recirculation bubbles occur, the first recirculation bubble is found to be stable to 3-D perturbations, but not the second one. Asymmetric amplification is concentrated at the second bubble. Hence, the flow has the appearance of bubble breakdown upstream and a downstream spiral breakdown. When the axisymmetric solution exhibits regular vortex shedding behavior, the shed ring vortices are found to be stretched and spiraling around an almost axisymmetric core. The flow appears to have a front end axisymmetric bubble, followed by a spiraling tail. When spiraling occurs, the first harmonic component dominates the asymmetric motion. Dissert. Abstr.

N93-25883*# Toledo Univ., OH.
ESTIMATING TURBINE LIMIT LOAD Final Report
ARTHUR J. GLASSMAN Apr. 1993 10 p
(Contract NAG3-1165; RTOP 505-69-50)
(NASA-CR-191105; E-7705; NAS 1.26:191105) Avail: CASI HC A02/MF A01

A method for estimating turbine limit-load pressure ratio from turbine map information is presented and demonstrated. It is based on a mean line analysis at the last-rotor exit. The required map information includes choke flow rate at all speeds as well as pressure ratio and efficiency at the onset of choke at design speed. One- and two-stage turbines are analyzed to compare the results with those from a more rigorous off-design flow analysis and to show the sensitivities of the computed limit-load pressure ratios to changes in the key assumptions. Author

N93-25894# RAND Corp., Santa Monica, CA.
NUMERICAL SIMULATION OF HYPERSONIC AERODYNAMICS AND THE COMPUTATIONAL NEEDS FOR THE DESIGN OF AN AEROSPACE PLANE
S. K. LIU 1992 147 p
(Contract F49620-91-C-0003)
(AD-A260681; RAND/N-3253-AF) Avail: CASI HC A07/MF A02

This Note records the results of a review and analysis of the status of the computational fluid dynamic (CFD) modeling techniques related to the National Aerospace Plane (NASP) operation. It was undertaken as a task in the study, The National Aerospace Plane (NASP): Development Issues for Follow-on Systems, performed within the Technology Applications Program of Project AIR FORCE. The research sought to evaluate independently the degree of uncertainty and the technical risk involved in predicting the NASP performance using numerical

simulation of aerothermal and chemical/combustion processes. This Note covers the technical review portion and identifies the areas for research emphasis so that the predictive reliability of the NASP's potential performance parameters can be improved. This study should interest those concerned with the aerospace plane development in general, and hypersonic CFD modeling in particular. DTIC

N93-26007 Wright Lab., Wright-Patterson AFB, OH.
STUDIES IN AIR/AIR SUPERSONIC MIXING LAYERS
D. J. RISHA and B. SEKAR *In* JHU, 29th JANNAF Combustion Subcommittee Meeting, Volume 2 p 9-18 Oct. 1992
Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

Results for the numerical simulation of a two-dimensional, supersonic, air-to-air shear layer with convective Mach numbers of 0.1 and 0.46 are presented. A two-dimensional Navier-Stokes code (SPARK2D), using a 4th order, cross MacCormack, time-accurate integration scheme is used to numerically solve the flow equations. Two versions of the code are used: (1) direct numerical simulations (DNS), and a two-equation k-epsilon turbulence model. Comparison of the DNS solutions with experimental results shows similar trends in the shear layer growth rate and the statistical parameters (stream wise turbulent intensity, transverse turbulent intensity, kinematic Reynolds stress) but at reduced magnitudes. Comparison of the k-epsilon simulated solutions with experimental results also showed similar trends in the shear layer growth rate and statistical parameters and are moderately comparable in magnitudes. However, all simulated results degrade with increasing convective Mach number. The validity and requirements of the DNS towards simulating a realistic laboratory test is argued in light of the available lessons learned and weighed against the engineering approaches. Author

N93-26049*# Pennsylvania State Univ., University Park.
REDUCTION IN SIZE AND UNSTEADINESS OF A VTOL GROUND VORTEX BY GROUND FENCES
JOHN M. CIMBALA, MICHAEL L. BILLET, and TODD B. HARMAN 15 Apr. 1993 23 p
(Contract NAG2-484)
(NASA-CR-192997; NAS 1.26:192997) Avail: CASI HC A03/MF A01

A ground vortex, produced when a jet impinges on the ground in the presence of cross flow, is encountered by V/STOL aircraft hovering near the ground and is known to be hazardous to the aircraft. The objective of this research was to identify a ground-based technique by which both the mean size and fluctuation in size of the ground vortex could be reduced. A simple passive method was identified and examined in the laboratory. Specifically, one or two fine wire mesh screens (ground fences) bent in a horseshoe shape and located on the ground in front of the jet impingement point proved to be very effective. The ground fences work by decreasing the momentum of the upstream-traveling wall jet, effectively causing a higher freestream-to-jet velocity ratio (V(sub infinity)/V(sub j)) and thus, a ground vortex smaller in size and unsteadiness. At(V(sub infinity)/V(sub j)) = 0.15, the addition of a single ground fence resulted in a 70 percent reduction in mean size of the ground vortex. With two ground fences, the mean size decreased by about 85 percent. Fluctuations in size decreased nearly in proportion to the mean size, for both the single and double fence configurations. These results were consistent over a wide range of jet Reynolds number (10(exp 4) less than Re(sub jet) less than 10(exp 5)); further development and full-scale Reynolds number testing are required, however, to determine if this technique can be made practical for the case of actual VTOL aircraft. Author (revised)

N93-26078*# Houston Univ., TX. Dept. of Mathematics.
A HYBRID MULTIGRID TECHNIQUE FOR COMPUTING STEADY-STATE SOLUTIONS TO SUPERSONIC FLOWS Final Report
RICHARD SANDERS *In* NASA. Johnson Space Center, National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1992, Volume 2 p 16 Dec. 1992
(Contract NGT-44-001-800)
Avail: CASI HC A03/MF A02

Recently, Li and Sanders have introduced a class of finite difference schemes to approximate generally discontinuous solutions to hyperbolic systems of conservation laws. These equations have the form together with relevant boundary conditions. When modelling hypersonic spacecraft reentry, the differential equations above are frequently given by the compressible Euler equations coupled with a nonequilibrium chemistry model. For these applications, steady state solutions are often sought. Many tens (to hundreds) of super computer hours can be devoted to a single three space dimensional simulation. The primary difficulty is the inability to rapidly and reliably capture the steady state. In these notes, we demonstrate that a particular variant from the schemes presented can be combined with a particular multigrid approach to capture steady state solutions to the compressible Euler equations in one space dimension. We show that the rate of convergence to steady state coming from this multigrid implementation is vastly superior to the traditional approach of artificial time relaxation. Moreover, we demonstrate virtual grid independence. That is, the rate of convergence does not depend on the degree of spatial grid refinement. Author

N93-26085*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL EFFECTS OF WING LOCATION ON WING-BODY PRESSURES AT SUPERSONIC SPEEDS
JERRY M. ALLEN and CAROLYN B. WATSON Apr. 1993 198 p
(Contract RTOP 505-59-30-01)
(NASA-TM-4434; L-17148; NAS 1.15:4434) Avail: CASI HC A09/MF A03

An experimental study was performed at supersonic speeds to measure wing and body spanwise pressure distributions on an axisymmetric-body delta wing model on which the wing vertical location on the body was systematically varied from low- to high-mounted positions. In addition, for two of these positions both horizontal and radial wing angular orientations relative to the body were tested, and roll angle effects were investigated for one of the positions. Seven different wing-body configurations and a body-alone configuration were studied. The test was conducted at Mach numbers from 1.70 to 2.86 at angles of attack from about -4 deg to 24 deg. Pressure orifices were located at three longitudinal stations on each wing-body model, and at each station the orifices were located completely around the body, along the lower surface of the right wing (looking upstream), and along the upper surface of the left wing. All pressure coefficient data are tabulated and selected samples are shown graphically to illustrate the effects of the test variables. The effects of angle of attack, roll angle, Mach number, longitudinal station, wing vertical location, wing angular orientation, and wing-body juncture are analyzed. The vertical location of the wing on the body had a very strong effect on the body pressures. For a given angle of attack at a roll angle of 0 deg, the pressures were virtually constant in the spanwise direction across the windward surfaces of the wing-body combination. Pressure-relieving, channeling, and vortex effects were noted in the data. Author (revised)

N93-26099*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
JET-INDUCED GROUND EFFECTS ON A PARAMETRIC FLAT-PLATE MODEL IN HOVER
DOUGLAS A. WARDWELL, CRAIG E. HANGE, RICHARD E. KUHN (KSA Technology, Columbus, OH.), and VEARL R. STEWART (KSA Technology, Columbus, OH.) Mar. 1993 306 p
(Contract RTOP 505-68-32)
(NASA-TM-104001; A-93040; NAS 1.15:104001) Avail: CASI HC A14/MF A03

The jet-induced forces generated on short takeoff and vertical landing (STOVL) aircraft when in close proximity to the ground can have a significant effect on aircraft performance. Therefore,

accurate predictions of these aerodynamic characteristics are highly desirable. Empirical procedures for estimating jet-induced forces during the vertical/short takeoff and landing (V/STOL) portions of the flight envelope are currently limited in accuracy. The jet-induced force data presented significantly add to the current STOVL configurations data base. Further development of empirical prediction methods for jet-induced forces, to provide more configuration diversity and improved overall accuracy, depends on the viability of this STOVL data base. The data base may also be used to validate computational fluid dynamics (CFD) analysis codes. The hover data obtained at the NASA Ames Jet Calibration and Hover Test (JCAHT) facility for a parametric flat-plate model is presented. The model tested was designed to allow variations in the planform aspect ratio, number of jets, nozzle shape, and jet location. There were 31 different planform/nozzle configurations tested. Each configuration had numerous pressure taps installed to measure the pressures on the undersurface of the model. All pressure data along with the balance jet-induced lift and pitching-moment increments are tabulated. For selected runs, pressure data are presented in the form of contour plots that show lines of constant pressure coefficient on the model undersurface. Nozzle-thrust calibrations and jet flow-pressure survey information are also provided. Author (revised)

N93-26134*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONICAL EULER ANALYSIS AND ACTIVE ROLL SUPPRESSION FOR UNSTEADY VORTICAL FLOWS ABOUT ROLLING DELTA WINGS
ELIZABETH M. LEE-RAUSCH and JOHN T. BATINA Mar. 1993 30 p Original contains color illustrations
(Contract RTOP 505-63-50-12)
(NASA-TP-3259; L-17059; NAS 1.60:3259) Avail: CASI HC A03/MF A01; 3 functional color pages

A conical Euler code was developed to study unsteady vortex-dominated flows about rolling, highly swept delta wings undergoing either forced motions or free-to-roll motions that include active roll suppression. The flow solver of the code involves a multistage, Runge-Kutta time-stepping scheme that uses a cell-centered, finite-volume, spatial discretization of the Euler equations on an unstructured grid of triangles. The code allows for the additional analysis of the free to-roll case by simultaneously integrating in time the rigid-body equation of motion with the governing flow equations. Results are presented for a delta wing with a 75 deg swept, sharp leading edge at a free-stream Mach number of 1.2 and at 10 deg, 20 deg, and 30 deg angle of attack alpha. At the lower angles of attack (10 and 20 deg), forced-harmonic analyses indicate that the rolling-moment coefficients provide a positive damping, which is verified by free-to-roll calculations. In contrast, at the higher angle of attack (30 deg), a forced-harmonic analysis indicates that the rolling-moment coefficient provides negative damping at the small roll amplitudes. A free-to-roll calculation for this case produces an initially divergent response, but as the amplitude of motion grows with time, the response transitions to a wing-rock type of limit cycle oscillation, which is characteristic of highly swept delta wings. This limit cycle oscillation may be actively suppressed through the use of a rate-feedback control law and antisymmetrically deflected leading-edge flaps. Descriptions of the conical Euler flow solver and the free-to roll analysis are included in this report. Results are presented that demonstrate how the systematic analysis of the forced response of the delta wing can be used to predict the stable, neutrally stable, and unstable free response of the delta wing. These results also give insight into the flow physics associated with unsteady vortical flows about delta wings undergoing forced motions and free-to-roll motions, including the active suppression of the wing-rock type phenomenon. The conical Euler methodology developed is directly extend able to three-dimensional calculations. Author (revised)

N93-26195# Naval Postgraduate School, Monterey, CA.
TRAILING VORTEX/FREE-SURFACE INTERACTION M.S. Thesis
DONALD E. NEUBERT, JR. Dec. 1992 81 p
(AD-A261654) Avail: CASI HC A05/MF A01

An investigation of the interaction of a trailing vortex with a free surface has been undertaken for the purpose of understanding the origin of scars and striations. Velocity and turbulence measurements have been carried out through the use of a Laser-Doppler-Velocimeter (LDV) for various positions of the vortex relative to the free surface. The results have shown that the vortex motion affects the free surface and is affected by it. This mutual interaction leads to the development of surface scars comprised primarily of heterostrophic vortices normal to the free surface. Furthermore, the velocity and turbulence characteristics are affected such that the vertical components of turbulence decay rapidly, and the horizontal components stretch in the horizontal plane. The experiments have provided sufficient understanding of the physics of the phenomenon for the subsequent undertaking of the development of a predictive numerical model. DTIC

N93-26198# Naval Postgraduate School, Monterey, CA.
UNSTEADY AIRFOIL FLOW SOLUTIONS ON MOVING ZONAL GRIDS M.S. Thesis
ANTONIO M. CRICELLI 17 Dec. 1992 146 p
(AD-A261925) Avail: CASI HC A07/MF A02

Investigation of subsonic and transonic steady and unsteady flowfields over airfoils is an active area of current computational and experimental research. The performance of rotary wing and fixed wing aircraft can be enhanced by taking advantage of unsteady phenomena such as dynamic lift. However, several undesirable effects have prevented designers from taking advantage of these concepts. In the past few years many advances have been made in algorithm development for the numerical solution of the Euler and the Navier Stokes equations. In this study, these new techniques are applied to the body fixed zonal grid approach. This zonal approach is more computationally efficient in solving the governing equations than previous approaches and has certain advantages over the standard single moving grid approach. The zonal grids consists of two grids: one being the inner grid which is fixed to the airfoil, and the other being the outer grid which extends to the far field or to a specified outer boundary. The inner grid is allowed to rotate with the body, while the outer grid remains fixed. The thin-layer Navier-Stokes equations are solved for the inner grid, and the Euler equations are solved for the outer grid. Communication between the two grids is accomplished by interpolating the flow quantities at the zonal interface. Solutions are obtained for flows at fixed angles of incidence, and for unsteady flows over pitching and oscillating airfoils. The computed results are in good agreement with available experimental data. DTIC

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AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A93-34616
NEW EUROPEAN REGULATIONS FOR ROTORCRAFT; PROCEEDINGS OF THE CONFERENCE, LONDON, UNITED KINGDOM, MAR. 16, 1993
London Royal Aeronautical Society 1993 74 p. No individual items are abstracted in this volume
(ISBN 1-85768-085-5) Copyright

The present conference discusses year-2000 safety standards for helicopters in Europe, the legal bases for the creation of European rotorcraft regulatory frameworks, and recent European operating regulations for rotorcraft. Also discussed are new European community maintenance regulations, a rotorcraft

operator's response to new maintenance regulations, new rotorcraft airworthiness regulations, and a helicopter manufacturer's view of airworthiness regulations. AIAA

A93-35152#
STABLE CROSS TYPE PARACHUTE WITH INFLATION AID
KARL-FRIEDRICH DOHERR (DLR, Inst. fuer Flugmechanik, Braunschweig, Germany) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 1-3. refs
(AIAA PAPER 93-1201) Copyright

To improve its inflation characteristics a stable version of the cross type parachute was equipped with a pressurized plastic tube attached to the square roof of the canopy. Low altitude drop tests were made with a 13.85-m version of the so-called LAP-LEONARDO canopy. For example, a 100-kg payload was dropped from a transport aircraft and from a helicopter in horizontal flight at altitudes between 50 to 80 m. On landing the canopy was always fully inflated, and the trajectory was vertical. Also, no severe oscillations of the system were observed. Author (revised)

A93-35154#
RECENT ADVANCES IN THE NUMERICAL ANALYSIS OF RAM AIR WINGS - THE THREE DIMENSIONAL SIMULATION CODE 'PARA3D'
T. CHATZIKONSTANTINOU (Arithmotechniki, Ltd., Salonika, Greece) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 13-23. refs
(AIAA PAPER 93-1203) Copyright

This paper presents a numerical method for predicting the behavior of ram air wings under aerodynamic loading. Their shape in flight cannot be found unless the pressure distribution is known, and the pressure cannot be found unless the shape is known. It follows that both aerodynamic and structural problems have to be solved simultaneously. Three-dimensional simulation examples of real ram air wings demonstrate that this highly nonlinear coupled problem can be solved numerically with a combined finite element-vortex lattice representation of the structure and sophisticated iterative techniques. The accuracy of the method allows the application in the design practice. Author (revised)

A93-35155#
DEVELOPMENT TESTING OF LARGE RAM AIR INFLATED WINGS
W. K. WAILES (Pioneer Aerospace Corp., Melbourne, FL) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 24-32.
(AIAA PAPER 93-1204) Copyright

The airdrop testing of large ram air inflated wings from 1988 to 1992 is addressed. Testing techniques and test-peculiar hardware were based on previously employed hardware/techniques. Airdrop subtask results have largely met the development objectives (demonstration of first-stage inflation, disreef and inflation, stability of reefed stages, and flared landing; measurement of deployment loads, transition glide, steady-state glide, and control line force/deflection; and evaluation of reefing ratios) and have relevance for derivative high glide applications. Kevlar-to-Kevlar abrasion damage, test vehicle stability, premature disreef, and bagstrip damage are also discussed. AIAA

A93-35157#
A SIMPLE, APPROXIMATE MODEL OF PARACHUTE INFLATION
J. M. MACHA (Sandia National Labs., Albuquerque, NM) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 44-53. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 93-1206)

A simple, approximate model of parachute inflation is described. The model is based on the traditional, practical treatment of the fluid resistance of rigid bodies in nonsteady flow, with appropriate modifications to account for the changing shape of the canopy. Steady-flow, fixed-geometry correlations for the drag and radial force are required as input to the dynamic model. In a novel approach, the radial force is expressed in terms of easily obtainable drag and reefing line tension measurements. A series of wind tunnel experiments provides the needed correlations. Coefficients associated with the added mass of fluid are evaluated by calibrating the model against an extensive and reliable set of flight data. A parameter is introduced which appears to universally govern the strong dependence of the axial added mass coefficient on motion history. Through comparisons with flight data, the model is shown to realistically predict inflation forces for ribbon and ringslot canopies over a wide range of sizes and deployment conditions. Author (revised)

A93-35158#
THE EFFECT OF EXTREME ALTITUDE ON PARACHUTE FILLING DISTANCE
GEORGE A. BARNARD (CDR Parachute Systems, Burlington, MA) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 54-61. refs
(AIAA PAPER 93-1207) Copyright

Conservation of Momentum is used to extend the envelope of application of the filling-distance concept to altitudes above the stratosphere. A simple multiplying factor for filling distance is derived. The analysis predicts that, at extreme altitude, canopy dynamics can increase filling distance to several times its sea-level value. The result suggests severe criteria of size and lightness for super-stratospheric parachutes. Author

A93-35159#
RADIAL REEFING METHOD FOR ACCELERATED AND CONTROLLED PARACHUTE OPENING
CALVIN K. LEE (U.S. Army, Natick Research, Development, and Engineering Center, MA) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 62-71. refs
(AIAA PAPER 93-1209)

Future Army airdrop systems will require aerial insertion of cargo and personnel from low altitudes to minimize ground-fire hazards. A radial reefing method was developed as a potential candidate to meet this requirement. This paper presents the concept, procedure, and full-scale test results of the method. It is found that the radial reefing method shows promise for low-altitude airdrop applications. In addition, the method also improves parachute opening by minimizing canopy enfolding and slumping. Author

A93-35162#
APPLICATION OF PARAFOILS TO MICROWAVE LANDING SYSTEM SITING
GARY L. VIVIANI (Textron Defense Systems, Wilmington, MA) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 90-99. refs
(AIAA PAPER 93-1213) Copyright

The task of determining the suitability of a landing zone, once the electronic landing aids are installed, is time consuming and costly in terms of manned flight operations, equipment and site availability. These analyses were undertaken to evaluate the

applicability of parafoils in order to minimize several measures of cost associated with flight certification of a landing zone. The primary motivations are reduced manned flight operations, improved accuracy and greatly reduced time to perform evaluations. A mathematical formulation and simulation results are provided.
Author

A93-35174#
THE DEVELOPMENT OF A PARACHUTE SYSTEM FOR AERIAL DELIVERY FROM HIGH SPEED CARGO AIRCRAFT
VANCE L. BEHR (Sandia National Labs., Albuquerque, NM) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 204-214. Research sponsored by U.S. Army refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 93-1232)

Supply of military personnel on the ground with cargo has long been accomplished with parachute delivery systems from aircraft. Structural limits of aircraft have typically limited these operations to no more than 150 KCAS. A desire for increased survivability of cargo delivery aircraft has led to the development and fielding of aircraft capable of delivering cargo at substantially higher speeds. This paper describes efforts undertaken to design develop and test a cargo delivery system for use at speeds compatible with those high speed cargo aircraft. Author

A93-35188#
PARACHUTE CANOPY CONTROL AND GUIDANCE TRAINING REQUIREMENTS AND METHODOLOGY
JEFFREY R. HOGUE, WALTER A. JOHNSON, R. W. ALLEN (Systems Technology, Inc., Hawthorne, CA), and DAVE PIERCE (USDA, Equipment Development Center, Missoula, MT) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 311-319. refs
(AIAA PAPER 93-1255) Copyright

Training requirements and methodology for correct control and maneuver of steerable parachutes are discussed. Parachutists must learn to accurately sense visual motion cues, to predict their drift and trajectory, and then to control their parachutes appropriately to land safely in the desired landing zone. With ram-air parachutes, the jumper must make a controllability check for brake effects at half and full brakes. The jumper determines the stall position where the canopy rocks back in a stall and oscillates, and descent rate becomes hazardous. The advantages of simulator training - safety, availability, inexpensiveness, and effectiveness - are discussed. An interactive training simulator to reduce training and operational parachute landing injuries and to provide and maintain better and lower-cost training is also examined. AIAA

N93-24773 Cranfield Inst. of Tech., Bedford (England).
CRASHWORTHINESS OF COMPOSITE SEATS FOR CIVIL AIRCRAFT Ph.D. Thesis
V. M. STEPHENS 1992 283 p
Avail: Univ. Microfilms Order No. BRDX98009

Within these terms of reference, the response of the seat restraint occupant system (SROS) to impact loading was analyzed using physical (dynamic testing) and analytical (computer simulation) modeling techniques. With the increasing use of fiber-reinforced polymer composites in aircraft for weight efficiency, and the consequent appearance of composite seats, attention must be given to the crash performance of these structures. Composite structures are characterized by brittle failure with low impact energy absorption, in comparison to the collapse of metal structures which may exhibit plastic deformation prior to failure. However, using the developing technology of composite sub-structures with high specific energy absorption capability, seat structures were modified to incorporate composite load-limiting elements. The redesign process involved the compatibility of energy absorber loads with occupant dynamics to minimize injury potential, together with the alleviation of forces in the structural load path to reduce damage and preclude failure to the seat, floor track, and other components. Shortcomings of existing seat designs were assessed, and the dynamics of lap-belted occupants analyzed, including secondary head impact with the forward seat structure. Tne computer model created was validated against the results of dynamic tests, and then used in a parametric study of occupant dynamics. Conclusions and recommendations include guidelines relating to the future design of both metal and composite seats. Dissert. Abstr.

N93-24879# Aerospatiale, Suresnes (France). Centre Commun de Recherches.
NUMERICAL MODELLING OF INDUCED EFFECTS OF LIGHTNING STRIKE ON AN ALL COMPOSITE HELICOPTER
PASCAL GONDOT, G. DONNET (Nucletudes, Montreuil, France.), and PATRICK TROCHET (Nucletudes, Montreuil, France.) *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 11 p Nov. 1992
Avail: CASI HC A03/MF A03

The use of Carbon Fiber Composite in airframe construction arouses an increase of interest to protect sensitive avionic systems against indirect effects of lightning. In the SAE-AE4L recommendation, a long duration waveform is specified for equipment tests, especially in the case of an all composite structure. An all composite helicopter has been modeled with a FDTD method including internal structures and cables network. Then, the induced currents on shielded cables have been calculated for three lightning strike configurations. The purpose of this study is to discuss a specification for equipment tests based on calculations which permit us to distinguish typical waveforms and levels of transient for every equipment. Author

N93-24880# Rockwell International Corp., Downey, CA. Space Systems Div.
ZONING OF AIRCRAFT: A REVIEW OF THE DEFINITIONS
NATHANIEL G. BANKSTON *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 16 p Nov. 1992
Avail: CASI HC A03/MF A03

The assignment of lightning strike zones to the surface areas of aircraft is a necessary first step in the protection design and certification process. Lightning strike zones are defined with respect to an external environment that has been synthesized from the important characteristics of natural lightning. Based on recent discussions in the Society of Automotive Engineers (SAE) AE4-L committee on lightning standards, it is apparent that the zone definitions are not intuitively clear. This paper presents a review of the zone definitions and discusses some of the problems associated with these definitions, including the problem of making probability statements in the definitions. Author

N93-24885# Northrop Corp., Pico Rivera, CA.
A PROCEDURE FOR DEFINING LIGHTNING RISK TO AIR VEHICLES
DAVID BEEMAN and NAOMI MORITA *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 18 p Nov. 1992
Avail: CASI HC A03/MF A03

The risk of a lightning-induced failure is a function of the atmospheric conditions which produce lightning and the protective characteristics of the vehicle. Contemporary air vehicle designs - which incorporate 'wet' wings and extensive composite skin and structures - require thorough consideration of this risk to balance performance of lightning protection measures against other performance parameters (i.e., cost, weight, manufacturability, maintainability). An analytic procedure to investigate the risk of lightning-induced fuel vapor ignition is described in this paper. Sensitivity of the risk to various atmospheric and air vehicle design parameters was examined and is discussed. Author

N93-24886# United Kingdom Atomic Energy Authority, Abingdon (England). Lightning Test and Technology.

PARAMETERS INFLUENCING THE HOT-SPOT IGNITION OF AVIATION FUEL/AIR AND ETHYLENE/AIR MIXTURES

STEPHEN J. HAIGH and C. JOHN HARDWICK *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 9 p Nov. 1992 Sponsored by British Aerospace Aircraft Group; Civil Aviation Authority; Construcciones Aeronauticas S.A.; Dept. of Trade and Industry; Rolls-Royce Ltd.; Saab-Scania; and Short Bros. and Harland Ltd.
Avail: CASI HC A02/MF A03

Lightning attachments to aircraft skins can lead to the creation of local areas of heating or 'hotspots', which may be able to ignite fuel/air vapor mixtures contained within the skin. The characteristic temperature/time histories of such hot-spots are very different depending on whether the skins are metallic or carbon fiber. This report describes experimental work carried out under the Lightning Club program to determine the ability of transient hot-spots in metal foil to ignite JP4/air mixtures. The influence of parameters such as hot-spot size and duration is considered, as well as fuel concentration and oxygen enrichment. To establish the validity of simulation testing techniques in which ethylene is used to detect hotspots, some experiments are also carried out using mixtures of this gas with air. We make comparison of these with results with other reported work in this field. Author

N93-24887# SRI International Corp., Menlo Park, CA.

COMPARISON OF THE ELECTRICAL CHARGING AND DISCHARGING ENVIRONMENTS OF MULTIPLE AIRCRAFT-BORNE ELECTRIC-FIELD MEASUREMENT SYSTEMS

KATHY L. GIORI and J. E. NANEVICZ *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 10 p Nov. 1992
Avail: CASI HC A02/MF A03

Various aircraft and particle charging and discharging mechanisms can adversely affect the performance of aircraft-borne electric-field measurement systems. Samples of data collected both during coordinated flight maneuvers (T-28 and SPTVAR aircraft) and from similar flight environments (Learjets 24B and 36A) have been analyzed and compared. These comparisons help in the identification and interpretation of the possible effects of (1) charged particles, and (2) aircraft charging and discharging phenomena on the respective electric-field measuring systems. It was found that the SPTVAR generally became more highly charged than the T-28, and the Learjet 36A more than the 24B. Such comparisons offer a better understanding of the electrical characteristics and of the measurement accuracies of these systems. Author

N93-24894# United Kingdom Atomic Energy Authority, Abingdon (England). Lightning Test and Technology.

ZONING OF AIRCRAFT BY ELECTRIC FIELD MODELLING

C. JOHN HARDWICK and V. K. THOMPSON *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 10 p Nov. 1992 Sponsored by British Aerospace Aircraft Group; Construcciones Aeronauticas S.A.; Rolls-Royce Ltd.; Saab-Scania; Short Bros. and Harland Ltd.; Westland Helicopters Ltd.; Civil Aviation Authority; and Dept. of Trade and Industry
Avail: CASI HC A02/MF A03

The accurate determination of the zoning of aircraft has become more important with the increasing use of CFC materials in airframe construction. In-flight evidence suggests previous rules such as those given in the FAA AC20-53A are unsatisfactory. The proposed AC20-53B recommends substantially increased areas for Zone 1A. This paper presents an approach for calculating the initial attachment zones which, unlike the rolling sphere model, explicitly takes field concentration factors into account. Author

N93-24898# Naval Air Warfare Center, Patuxent River, MD. Aircraft Div.

APPLICATIONS OF STRESS ENVELOPE CONCEPTS TO AIRCRAFT EMP AND LIGHTNING SURVIVABILITY

SAM FRAZIER *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 6 p Nov. 1992
Avail: CASI HC A02/MF A03

The Naval Air Warfare Center Aircraft Division is conducting research into the modeling of aircraft electromagnetic transient response data. One result has been the development of a test point stress waveform which combines multiple responses. This single stress waveform bounds the test point stress responses collected during different test phases; each contributing waveform contains coupling response data from various polarizations, orientations, and configurations relative to the external threat environment. This new waveform, termed the 'Stress Envelope', has significant applications in the area of inductively coupled direct-drive, reducing test uncertainties, and permitting better estimates of system margins. Author

N93-25110# Sandia National Labs., Albuquerque, NM.

RELIABILITY ASSESSMENT AT AIRLINE INSPECTION FACILITIES. VOLUME 1: A GENERIC PROTOCOL FOR INSPECTION RELIABILITY EXPERIMENTS Final Report

FLOYD SPENCER, GIANCARLO BORGONOVI (Science Applications, Inc., Albuquerque, NM.), DENNIS ROACH, DON SCHURMAN (Science Applications, Inc., Albuquerque, NM.), and RON SMITH (AEA Technology, London, England.) Mar. 1993 34 p
(DOT/FAA/CT-92/12-VOL-1) Avail: CASI HC A03/MF A01

The Aging Aircraft Nondestructive Inspection (NDI) Development and Demonstration Center (AANC) at Sandia National Laboratories is charged by the FAA to support technology transfer, technology assessment, and technology validation. A key task facing the center is to establish a consistent and systematic methodology to assess the reliability of inspections through field experiments. This task is divided into three major areas: reliability of eddy current lap splice inspections at transport aircraft maintenance facilities, reliability of inspection at commuter aircraft maintenance facilities, and reliability of inspection associated with visual inspection of aircraft structural parts. Volume 1 is the first document in a series of three describing the planning, execution, and results of an eddy current inspection field experiment. A generic protocol for inspection reliability experiments is defined. It contains an introduction to the currently accepted forms of data analysis and presentation (Probability of Detection and Receiver Operating Characteristic curves) and a discussion of the factors that may affect inspection reliability. Author (revised)

N93-25205# Federal Aviation Administration, Oklahoma City, OK. Civil Aeromedical Inst.

INWARD CONTAMINANT LEAKAGE TESTS OF THE S-TRON CORPORATION EMERGENCY ESCAPE BREATHING DEVICE. PHASE 1: TESTS OF THE ORIGINAL DESIGN. PHASE 2: TESTS WITH THE REDESIGNED NECK SEAL

BRUCE C. WILCOX, JR., HARVEY M. ENGLAND, JR., and GARNET A. MCLEAN Apr. 1992 28 p
(Contract FAA PROJ. AM-B-93-PHY-152)
(DOT/FAA/AM-92/18) Avail: CASI HC A03/MF A01

At the request of S-Tron Corporation, to support their contract with the U.S. Navy, performance tests of the Emergency Escape Breathing Device (EEBD) were conducted in the Environmental Physiology Research Section contaminant leakage chamber. Sulfur hexafluoride (SF6) challenge was used to determine contaminant leakage; oxygen and carbon dioxide levels, as well as temperature readings, were also obtained. Eight successful tests were conducted with the original neck seal design first used by Scott Aviation in their Crewmember Protective Breathing Equipment, four additional tests were conducted with a proprietary new neck seal designed by S-Tron. The EEBD all performed within test limits. Author

N93-25224# Federal Aviation Administration, Atlantic City, NJ.
NARROW-BODY AIRCRAFT WATER SPRAY OPTIMIZATION STUDY
TIMOTHY R. MARKER Feb. 1993 39 p Original contains color illustrations
(DOT/FAA/CT-TN93/3) Avail: CASI HC A03/MF A01

Twenty-five full-scale tests were conducted in a modified 707 narrow-body fuselage as part of an aircraft cabin water spray optimization study. The purpose was to test several spray configurations by varying the amount of water sprayed, the flow rate, and orientation of the nozzles, while keeping the fire conditions constant, in an attempt to minimize the quantity of water required to effectively suppress a postcrash aircraft fire and improve occupant survivability. The original Safety Aircraft and Vehicles Equipment (SAVE) system was configured in the narrow-body cabin using 120 nozzles. Initially, three tests were conducted using 72, 48, and 24 gallons of water for 3-, 2-, and 1-minute spray durations, respectively. In the following series of tests, one-third of the SAVE system (40 nozzles) was configured in the area of the fire using 24, 16, and 8 gallons of water for 3-, 2-, and 1-minute spray durations, respectively. During the final series of tests, the spray system was configured in five separate sections for 'zones' with each zone carrying eight nozzles. A thermocouple was mounted at ceiling height in each zone, allowing for the activation of a particular zone when the temperature reached a predetermined value. The flow rate of the nozzles was varied as was the amount of water available during the tests. For comparison, a test was conducted without spraying water in order to establish a 'baseline.' Temperature, heat flux, smoke levels, gas concentrations, and video were continuously monitored at various locations throughout the fuselage. The optimal zoned system was more effective than the SAVE system and used only 11 percent of the water.
Author (revised)

N93-25827# National Transportation Safety Board, Washington, DC.
AIRCRAFT ACCIDENT REPORT: TOMY INTERNATIONAL, INC., D/B/A SCENIC AIR TOURS FLIGHT 22, BEECH MODEL E18S, N342E IN-FLIGHT COLLISION WITH TERRAIN, MOUNT HALEAKALA, MAUI, HAWAII, 22 APRIL 1992
2 Feb. 1993 67 p
(PB93-910401; NTSB/AAR-93/01) Avail: CASI HC A04/MF A01

This report explains Scenic Air Tours flight 22's collision with mountainous terrain on the Island of Maui, Hawaii, while the Beech E18S airplane was on an air tour flight from Hilo, Hawaii, to Honolulu, Hawaii, on 22 Apr. 1992. The safety issues discussed in the report include visual flight in instrument meteorological conditions, navigational errors, pilot preemployment qualifications and background checks, and the overall safety of the air tour industry. Recommendations concerning these issues were addressed to the Federal Aviation Administration and to Tomy International, Inc., d/b/a Scenic Air Tours. Author (revised)

N93-25896# Civil Aeromedical Inst., Oklahoma City, OK.
A REVIEW OF CIVIL AVIATION PROPELLER-TO-PERSON ACCIDENTS: 1980-1989 Final Report
WILLIAM E. COLLINS Jan. 1993 10 p
(AD-A260695; DOT/FAA/AM-93/2) Avail: CASI HC A02/MF A01

Various types of paint schemes on aircraft propeller and rotor blades are used to improve the visual conspicuity and attention-getting value of those blades when they are rotating. The improved conspicuity resulting from the paint schemes has the purpose of reducing the number of injuries and fatalities that might occur due to accidental contact with a rotating blade by pilots, passengers, or ground crew. The present study was undertaken to provide information regarding the circumstances surrounding such accidents in recent years and to compare those findings with the frequency and circumstances of propeller accidents during the 1965-1979 period. Computer retrievals of brief reports of all propeller accidents during the period from 1980 through 1989 were provided by the National Transportation Safety Board. Those reports were examined and analyzed in terms of type of accident, degree of injury, actions of pilots, action of passengers and ground crew, night or day, and other conditions. The computer search yielded a total of 104 reports of propeller-to-person accidents involving 106 persons. Prop-to-person accident frequency for the 1980-1989 period was notably lower than that previously reported for the 1960's and 1970's. Recent declines appear due to a combination of FAA educational efforts, economic conditions, and changes in the types of aircraft used by present aviation pilots. Irrespective of the decade under study, persons at most risk for a propeller-to-person accident are deplaning passengers and passengers attempting to assist the pilot prior to takeoff and after landing. DTIC

N93-26263# Army Aviation Applied Technology Directorate, Fort Eustis, VA.
PROAV CABLE WARNING SYSTEM (CWS) - U.S. ARMY AIRCRAFT INTEGRATION ASSESSMENT AND OCONUS FIELD EVALUATION Technical Report
KENT F. SMITH and ERIC C. LITTLETON Feb. 1993 125 p
(AD-A261233; USAATCOM-TR-93-D-1) Avail: CASI HC A06/MF A02

The PROAV Cable Warning System (CWS) is a commercially available system designed to detect the electromagnetic field generated by current-carrying wires operating at frequencies of either 50 or 60 Hz. The system is designed to alert helicopter crewmen to the presence of these wires to help prevent wire strike mishaps. As directed by the U.S. Army Aviation and Troop Command, the Aviation Applied Technology Directorate performed an aircraft integration assessment of the CWS followed by field evaluations in Germany and Korea. These field evaluations were not operational tests, since no standard or specification exists by which to judge this system. The CWS was successfully integrated on the AH-64A, AH-1F, and UH-1H aircraft. During the field evaluations, the CWS was flown a total of 207 hours by 40 different pilots. The conclusions were that the CWS was not consistent in its ability to detect wires and provide sufficient reaction time and that pilot confidence in the capabilities of the CWS was marginal to low. Also, significant aircraft integration issues remain unresolved for several U.S. Army fleet aircraft. DTIC

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

N93-24741# Federal Aviation Administration, Atlanta, GA.
ILS MATHEMATICAL MODELING STUDY OF AN ILS GLIDE SLOPE PROPOSED FOR RUNWAY 19L AT THE MERIDIAN NAVAL AIR STATION, MISSISSIPPI Technical Report, Feb. 1993
JAMES D. RAMBONE Apr. 1993 19 p
(Contract FAA-T0603-S)
(DOT/FAA/CT-TN93/8) Avail: CASI HC A03/MF A01

This Technical Note describes the Instrument Landing System (ILS) math modeling performed by the Federal Aviation Administration (FAA) Technical Center at the request of the Naval Command, Control, and Ocean Surveillance Center In-Service Engineering (NISE). Data are presented showing the computed performance for a glide slope proposed for runway 19L at the Meridian Naval Air Station (NAS). As requested, capture effect and null reference systems were modeled at the proposed glide slope site. The proposed site is located 783 feet back from the runway threshold and 400 feet left offset of centerline. NISE is concerned that severe terrain gradients in front of the site may adversely affect glide slope performance. Glide slope modeling was conducted using physical optics computations in the Geometric Theory of Diffraction 3D (GTD-3D) model. The GTD computations in the GTD-3D model could not accommodate a triple diffraction

occurrence caused by sharp terrain gradients in front of the glide slope site. Glide slope modeling computed only the effect of the proposed terrain on glide slope performance. Preliminary modeling results for both the capture effect and null reference antennas with the proposed terrain grade indicated an out-of-tolerance excursion occurring approximately 3,000 feet in front of threshold. The first 1,000 foot section of proposed terrain grade in front of the antenna was modified slightly to eliminate this excursion in the final modeling runs. Modeled path structure and level run plots are provided for the proposed capture effect and null reference systems. Results indicate that the capture effect and null reference systems modeled with the modified proposed terrain grade should meet Category 1 path structure, linearity, and symmetry tolerances. Author (revised)

N93-24914*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DISCRETE RANGE CLUSTERING USING MONTE CARLO METHODS
G. B. CHATTERJI and B. SRIDHAR Mar. 1993 16 p
(Contract RTOP 505-64-36)
(NASA-TM-104004; A-93044; NAS 1.15:104004) Avail: CASI HC A03/MF A01

For automatic obstacle avoidance guidance during rotorcraft low altitude flight, a reliable model of the nearby environment is needed. Such a model may be constructed by applying surface fitting techniques to the dense range map obtained by active sensing using radars. However, for covertness, passive sensing techniques using electro-optic sensors are desirable. As opposed to the dense range map obtained via active sensing, passive sensing algorithms produce reliable range at sparse locations, and therefore, surface fitting techniques to fill the gaps in the range measurement are not directly applicable. Both for automatic guidance and as a display for aiding the pilot, these discrete ranges need to be grouped into sets which correspond to objects in the nearby environment. The focus of this paper is on using Monte Carlo methods for clustering range points into meaningful groups. One of the aims of the paper is to explore whether simulated annealing methods offer significant advantage over the basic Monte Carlo method for this class of problems. We compare three different approaches and present application results of these algorithms to a laboratory image sequence and a helicopter flight sequence. Author

N93-24948# Federal Aviation Administration, Atlantic City, NJ.
VISUAL APPROACH DATA COLLECTION AT ST. LOUIS LAMBERT FIELD (STL) Final Report, 2 Aug. - 23 Oct. 1990
JAMES THOMAS, DOMINIC TIMOTEO, and AMY E. TRANSUE Jan. 1993 58 p
(Contract FAA-F2006-G)
(DOT/FAA/CT-TN93/2) Avail: CASI HC A04/MF A01

Data on aircraft executing simultaneous visual approaches to closely spaced parallel and intersecting runways were collected at Lambert - St. Louis International Airport (STL) between August 2 and October 23, 1990. The purpose of the data collection was to provide an accurate data base of the navigational characteristics of aircraft flying the 'fly visual' segment of the approach. Aircraft position data were collected using the in-place STL surveillance primary and secondary radars. The data were reduced and a limited analysis was performed at the Federal Aviation Administration (FAA) Technical Center by ATC Technology (ACD-340) personnel. The discussion in the Final Report concerns the accuracy of the collected position data and possible sources of error in the data collection. The reduced data were sent to the Standards Development Branch (AVN-540) for further analysis. AVN-540 will report on their findings and recommendations. Author (revised)

N93-25018# Kayser Threde G.m.b.H., Munich (Germany).
AN EXPERIMENTAL HEALTH MONITORING UNIT FOR GPS AND GLONASS
B. EISSFELLER, M. HAUNSCHILD (Maschinenfabrik Augsburg-Nuernberg A.G., Munich, Germany.), A. JANSCHE, and N. NIKLASCH (Maschinenfabrik Augsburg-Nuernberg A.G., Munich, Germany.) *In* ESA, Frequency and Time Forum p 253-257 Jun. 1992
(Contract ESA-9281/91/F/RD(SC))
Copyright Avail: CASI HC A01/MF A04

The development of an experimental Health Monitoring Unit (HMU) for GPS (Global Positioning System) and GLONASS (Russian Global Space Navigation System) is reported. The purpose of the HMU is to provide timely warnings to the navigation users if the satellite navigation systems should not be used for navigation. The monitoring unit is a key element in the integrity channel concept of a civil overlay Navsat to GPS and GLONASS. The most stringent requirements are those of civil aviation: in the nonprecision approach phase horizontal position errors exceeding the 600 m SPE threshold have to be reported within 10 seconds. The concept of the HMU is to use a GPS receiver as well as a GLONASS reveiver in a known location in order to detect large pseudorange errors and to identify the malfunctioning satellites. This means that the station is able to work autonomously. But it will also provide pseudorange errors compatible with the American RTCA SC-159 approach and for a future wide area DGPS (Differential GPS) system. ESA

N93-25120# Oak Ridge National Lab., TN.
USING FUZZY BEHAVIORS FOR THE OUTDOOR NAVIGATION OF A CAR WITH LOW-RESOLUTION SENSORS
F. G. PIN and Y. WATANABE 1993 7 p Presented at the Institute of Electrical and Electronics Engineers International Conference on Robotics and Automation, Atlanta, GA, 2-7 May 1993
(Contract DE-AC05-84OR-21400)
(DE93-002428; CONF-930519-5) Avail: CASI HC A02/MF A01

Vehicle control in a priori unknown, unpredictable, and dynamic environments requires many calculational and reasoning schemes to operate on the basis of very imprecise, incomplete, or unreliable data. For such systems, in which all the uncertainties can not be engineered away, approximate reasoning may provide an alternative to the complexity and computational requirements of conventional uncertainty analysis and propagation techniques. A proposed approach using superposition of elemental fuzzy behaviors to emulate human-like qualitative reasoning schemes is first discussed. A previously developed navigation scheme implemented on custom-designed very large scale integration (VLSI) fuzzy inferencing boards for indoor navigation of a small laboratory-type robot was progressively enhanced to investigate two control modes for driving a car in a priori unknown environments on the basis of sparse and imprecise sensor data. In the first mode, the car navigates fully autonomously, while in the second mode, the system acts as a driver's aid providing the driver with linguistic (fuzzy) commands to turn left or right and speed up or slow down depending on the obstacles perceived by the sensors. Experiments with both modes of control are described in which the system uses only three acoustic range (sonar) sensor channels to perceive the environment. Simulation results as well as indoors and outdoors experiments are presented and discussed to illustrate the feasibility of outdoor navigation using fuzzy behaviors operating on possibly very inaccurate sensor data. DOE

N93-25243# Federal Aviation Administration, Atlantic City, NJ.
RUNWAY VISUAL RANGE (RVR) OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION AND OT&E OPERATIONAL TEST REPORT
WILLIAM E. BRENNER, THOMAS C. CARTY, and JOSEPH J. GOSLIN Apr. 1993 94 p
(DOT/FAA/CT-TN93/37) Avail: CASI HC A05/MF A01

The Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing of the Runway Visual Range (RVR) was conducted at the Kansas City International (MCI) Airport Traffic Control Tower (ATCT) in Kansas City, MO, and at the Kansas City (ZKC) Air Route Traffic Control Center (ARTCC) in Olathe, KA. The purpose of this test was to verify National Airspace System (NAS) integration requirements of the subsystems and the operational effectiveness of the RVR within the NAS environment. The results of OT&E testing and the results of integration and

operational testing of the RVR/Maintenance Data Terminal (MDT) and RVR/ Maintenance Processing System (MPS) interface requirements are addressed. Testing of the Tower Control Computer Complex (TCCC) and the Automated Surface Observation System (ASOS) NAS subsystems was deferred. It was concluded that the New Generation RVR requires corrections and/or notifications to satisfactorily meet integration and operational requirements. The New Generation RVR should not be deployed until the deployment-critical issues detailed are resolved and successfully retested. The principal concerns pertain to (1) personnel safety, (2) product integrity during an equipment failure, and (3) accuracy of the visibility product. It is further recommended that all regression testing take place using the RVR and MPS operational baseline software. Author (revised)

N93-25261*# Ohio State Univ., Columbus. Cognitive Systems Engineering Lab.

DESIGN CONCEPTS FOR THE DEVELOPMENT OF COOPERATIVE PROBLEM-SOLVING SYSTEMS

PHILIP J. SMITH, ELAINE MCCOY (Nebraska Univ., Omaha.), CHUCK LAYTON (Galaxy Scientific Corp., Atlanta, GA.), and TOM BIHARI (Adaptive Machine Technologies, Inc., Columbia, OH.) 1992 34 p

(Contract NCC2-615)

(NASA-CR-192708; NAS 1.26:192708) Avail: CASI HC A03/MF A01

There are many problem-solving tasks that are too complex to fully automate given the current state of technology. Nevertheless, significant improvements in overall system performance could result from the introduction of well-designed computer aids. We have been studying the development of cognitive tools for one such problem-solving task, enroute flight path planning for commercial airlines. Our goal was two-fold. First, we were developing specific systems designs to help with this important practical problem. Second, we are using this context to explore general design concepts to guide in the development of cooperative problem-solving systems. These designs concepts are described. Author (revised)

N93-25330*# Ohio State Univ., Columbus. Cognitive Systems Engineering Lab.

DESIGN OF A COOPERATIVE PROBLEM-SOLVING SYSTEM FOR ENROUTE FLIGHT PLANNING: AN EMPIRICAL STUDY OF ITS USE BY AIRLINE DISPATCHERS Final Report

PHILIP J. SMITH, C. ELAINE MCCOY (Nebraska Univ., Omaha.), CHARLES LAYTON (Galaxy Scientific Corp., Atlanta, GA.), JUDITH ORASANU, SHERRY CHAPPEL, EV PALMER, and KEVIN CORKER (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.) 1993 69 p

(Contract NCC2-615)

(NASA-CR-192709; NAS 1.26:192709) Avail: CASI HC A04/MF A01

In a previous report, an empirical study of 30 pilots using the Flight Planning Testbed was reported. An identical experiment using the Flight Planning Testbed (FPT), except that 27 airline dispatchers were studied, is described. Five general questions were addressed in this study: (1) under what circumstances do the introduction of computer-generated suggestions (flight plans) influence the planning behavior of dispatchers (either in a beneficial or adverse manner); (2) what is the nature of such influences (i.e., how are the person's cognitive processes changed); (3) how beneficial are the general design concepts underlying FPT (use of a graphical interface, embedding graphics in a spreadsheet, etc.); (4) how effective are the specific implementation decisions made in realizing these general design concepts; and (5) how effectively do dispatchers evaluate situations requiring replanning, and how effectively do they identify appropriate solutions to these situations. Author (revised)

N93-25456# Mitre Corp., McLean, VA. Center for Advanced Aviation System Development.

THE DEPENDENT CONVERGING INSTRUMENT APPROACH PROCEDURE: AN ANALYSIS OF ITS SAFETY AND APPLICABILITY Final Report

ARTHUR P. SMITH, III, ANAND D. MUNDRA, DAVID R. BARKER, and GERALD A. DORFMAN Nov. 1992 197 p

(Contract DTFA01-89-C-00001)

(DOE/FAA/RD-93/6) Avail: CASI HC A09/MF A03

When an airport experiences low ceiling or visibility conditions the arrival capacity is significantly reduced. This is particularly true at airports that use both their main runway and their crosswind runway in Visual Meteorological Conditions (VMC). The consequence of this is an increase in delays. A concept for continuing to conduct approaches in Instrument Meteorological Conditions (IMC) to converging runways has been proposed which calls for coordinating the approaches to the two runways such that a stagger between the aircraft is maintained. This procedure is known as Dependent Converging Instrument Approaches (DCIA). This paper develops a DCIA procedure applicable to any runway geometry. The procedure is defined and modeled to capture its safety critical aspects. From this analysis recommendations are made concerning the stagger values and other factors relevant to applying this procedure safely. Author

N93-26052*# University of Central Florida, Orlando. Dept. of Industrial Engineering and Management Systems.

DESIGN OF AN AIR TRAFFIC COMPUTER SIMULATION SYSTEM TO SUPPORT INVESTIGATION OF CIVIL TILTROTOR AIRCRAFT OPERATIONS Final Report

RALPH V. ROGERS 15 Mar. 1993 180 p

(Contract NAG2-625)

(NASA-CR-192920; NAS 1.26:192920) Avail: CASI HC A09/MF A02

The TATSS Project's goal was to develop a design for computer software that would support the attainment of the following objectives for the air traffic simulation model: (1) Full freedom of movement for each aircraft object in the simulation model. Each aircraft object may follow any designated flight plan or flight path necessary as required by the experiment under consideration. (2) Object position precision up to +/- 3 meters vertically and +/- 15 meters horizontally. (3) Aircraft maneuvering in three space with the object position precision identified above. (4) Air traffic control operations and procedures. (5) Radar, communication, navaid, and landing aid performance. (6) Weather. (7) Ground obstructions and terrain. (8) Detection and recording of separation violations. (9) Measures of performance including deviations from flight plans, air space violations, air traffic control messages per aircraft, and traditional temporal based measures. Author

N93-26087*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PILOTED SIMULATION OF AN AIR-GROUND PROFILE NEGOTIATION PROCESS IN A TIME-BASED AIR TRAFFIC CONTROL ENVIRONMENT

DAVID H. WILLIAMS and STEVEN M. GREEN (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.) Apr. 1993 45 p

(Contract RTOP 505-64-13-01)

(NASA-TM-107748; NAS 1.15:107748) Avail: CASI HC A03/MF A01

Historically, development of airborne flight management systems (FMS) and ground-based air traffic control (ATC) systems has tended to focus on different objectives with little consideration for operational integration. A joint program, between NASA's Ames Research Center (Ames) and Langley Research Center (Langley), is underway to investigate the issues of, and develop systems for, the integration of ATC and airborne automation systems. A simulation study was conducted to evaluate a profile negotiation process (PNP) between the Center/TRACON Automation System (CTAS) and an aircraft equipped with a four-dimensional flight management system (4D FMS). Prototype procedures were developed to support the functional implementation of this process.

The PNP was designed to provide an arrival trajectory solution which satisfies the separation requirements of ATC while remaining as close as possible to the aircraft's preferred trajectory. Results from the experiment indicate the potential for successful incorporation of aircraft-preferred arrival trajectories in the CTAS automation environment. Fuel savings on the order of 2 percent to 8 percent, compared to fuel required for the baseline CTAS arrival speed strategy, were achieved in the test scenarios. The data link procedures and clearances developed for this experiment, while providing the necessary functionality, were found to be operationally unacceptable to the pilots. In particular, additional pilot control and understanding of the proposed aircraft-preferred trajectory, and a simplified clearance procedure were cited as necessary for operational implementation of the concept.
Author (revised)

N93-26093 Department of the Navy, Washington, DC.
SYSTEM FOR CALIBRATING A GYRO NAVIGATOR Patent
JOHN S. STAMBAUGH, inventor (to Navy) 24 Nov. 1992 4 p
Filed 31 Mar. 1989
(AD-D015668; US-PATENT-5,166,882;
US-PATENT-APPL-SN-349381; US-PATENT-CLASS-364-453)
Avail: US Patent and Trademark Office

The present invention relates to a system for calibrating translation equations of a gyro navigator of a submarine. A value of velocity and a value of position of the submarine are produced by using values of acceleration sensed by accelerometers in the navigation gyro. The value of velocity and position are produced with the aid of the translation equations. This value of velocity and value of position are compared with a value of velocity and a value position as produced by a more accurate and independent source. A comparison is made with the aid of Kalman filter. Any difference obtained during a comparison is used in order to calibrate the translation equations of the gyro navigator. DTIC

N93-26237# Army Aviation Technical Test Center, Fort Rucker, AL.
METHODOLOGY INVESTIGATION: GLOBAL POSITIONING SYSTEM INTEGRATION (GPS) Final Report, Oct. 1991 - Oct. 1992
LARRY K. MARTIN Jan. 1993 16 p
(AD-A261054) Avail: CASI HC A03/MF A01

Testing at U.S. Army Aviation Technical Test Center (ATTC), Fort Rucker, Alabama, requires nap-of-the-earth time space position information (TSPI) of rotary-wing aircraft integrated with other aircraft parameters. The Global Positioning System (GPS), integrated with other sensors, is expected to meet the TSPI requirements. This methodology investigation explored the requirements and the problems encountered in using the GPS for this purpose. DTIC

N93-26274# Army Topographic Engineering Center, Fort Belvoir, VA.
REPAIR, EVALUATION, MAINTENANCE, AND REHABILITATION RESEARCH PROGRAM. CONTINUOUS DEFORMATION MONITORING SYSTEM (CDMS) Final Report
CARL A. LANIGAN Dec. 1992 52 p
(AD-A261833; WES/TR/SL-REMR-CS-39) Avail: CASI HC A04/MF A01

The US Army Topographic Engineering Center (TEC) has developed an automated deformation monitoring technology known as the Continuous Deformation Monitoring System (CDMS). The CDMS is capable of computing structural deformation using the Global Positioning System (GPS) survey technology while operating in a continuous fashion over time. A network of two personal computers control GPS survey equipment and process the satellite data gathered to compute apparent structural deformation up to 24 times a day without the presence of an operator. Structural monitoring can take place at the project site or at a distant office. Performance testing by TEC has determined deformation measurement precision in the subcentimeter range. The CDMS was installed at Dworshak Dam in northern Idaho and tracked the upstream movement of the dam while undergoing reservoir drawdown. DTIC

N93-26447# Federal Aviation Administration, Oklahoma City, OK. Civil Aeromedical Inst.
CONVERSION OF THE CTA, INC., EN ROUTE OPERATIONS CONCEPTS DATABASE INTO A FORMAL SENTENCE OUTLINE JOB TASK TAXONOMY Final Report
MARK D. RODGERS and GENA K. DRECHSLER Jan. 1993 77 p
(AD-A261410; DOT/FAA/AM-93/1) Avail: CASI HC A05/MF A01

FAA Air Traffic Control Operations Concepts Volume VI: ARTCC-Host En Route Controllers (1990) developed by CTA, Inc., a technical description of the duties of an En Route air traffic control specialist (ATCS), formatted in User Interface Language, was restructured into a hierarchical formal sentence outline. To ensure that none of the meaning associated with a task or task element was lost during the conversion, the revised document was reviewed by subject matter experts (SME's) consisting of five groups of six En Route controllers and a quality assurance subject matter expert. SME's looked for words, phrases, or acronyms not commonly used by En Route controllers, and illogical sequencing of duties described in the document. Appropriate suggestions for change were implemented into the document before the next review. Five-hundred seventy-five changes were made to the document, with only two of these changes made during the final review, confirming that an improved document resulted from the research. The restructured document is intended to assist in the identification of tasks not performed or performed incorrectly during the commission of an operational error. However, an easily understood, detailed description of duties performed by an En Route ATCS has potential not only for use by researchers interested in En Route ATCS tasks, but also by quality assurance investigation teams and training personnel. DTIC

N93-26549*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
IMAGE-BASED RANGING AND GUIDANCE FOR ROTORCRAFT
P. K. A. MENON Dec. 1991 80 p
(Contract NCC2-575)
(NASA-CR-177608; A-93061; NAS 1.26:177608) Avail: CASI HC A05/MF A01

This report documents the research carried out under NASA Cooperative Agreement No. NCC2-575 during the period Oct. 1988 - Dec. 1991. Primary emphasis of this effort was on the development of vision based navigation methods for rotorcraft nap-of-the-earth flight regime. A family of field-based ranging algorithms were developed during this research period. These ranging schemes are capable of handling both stereo and motion image sequences, and permits both translational and rotational camera motion. The algorithms require minimal computational effort and appear to be implementable in real time. A series of papers were presented on these ranging schemes, some of which are included in this report. A small part of the research effort was expended on synthesizing a rotorcraft guidance law that directly uses the vision-based ranging data. This work is discussed in the last section. Author

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A93-33700
QUIET OPERATIONS KEY TO MD-90 SUCCESS

BRUCE A. SMITH Aviation Week & Space Technology (ISSN 0005-2175) vol. 138, no. 12 March 22, 1993 p. 42-44. Copyright

The MD-90, 153 to 172-passenger airliner has incorporated exceptionally quiet, aft-mounted V2500 engines in modified, acoustically-treated nacelles to meet current and projected airport noise regulations. An account is presently given of the means employed to reach the lower noise levels, as well as of the aircraft's configuration, specifications, and performance capabilities. AIAA

A93-33877*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLUTTER CALCULATIONS FOR FIXED AND ROTATING WINGS WITH STATE-SPACE INFLOW DYNAMICS

BRUCE D. NIBBELINK (Aerospace Corp., El Segundo, CA) and DAVID A. PETERS (Washington Univ., Saint Louis, MO) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 1-11. Research supported by U.S. Army and Georgia Inst. of Technology refs

(Contract NAG2-462)

(AIAA PAPER 93-1300) Copyright

A new p-type, finite-state, aerodynamic theory is used in the aeroelastic analyses of a fixed wing and a rotating wing in hover. The helicopter inflow theory is modified for application to a fixed-wing, or stopped-rotor configuration. The structural models are linear for both configurations, with elastic bending and torsion degrees of freedom. Results are compared with those using Theodorsen and Loewy theories, respectively, for the fixed and rotating wings. With the identification of both structural and nerodynamic modes, the involved frequency content of the flow is seen in a new, more detailed perspective. Author

A93-33909*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ENERGY-ABSORBING-BEAM DESIGN FOR COMPOSITE AIRCRAFT SUBFLOORS

HUEY D. CARDEN (NASA, Langley Research Center, Hampton, VA) and SOTIRIS KELLAS (Lockheed Engineering and Sciences Co., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 378-388. refs

(AIAA PAPER 93-1339) Copyright

Data have been presented from the design support testing of composite energy absorbing (EA) aircraft subfloor structures. The focus of the current study is the design and testing of subfloor structural concepts that would limit the loads transmitted to occupants to less than 20 g at crush speeds of approximately 30 fps. The EA composite subfloor is being designed to replace an existing noncrashworthy metallic subfloor in a composite aircraft prior to a full-scale crash test. A sandwich spar construction of a sine wave beam was chosen for evaluation and was found to have excellent energy absorbing characteristics. The design objective of obtaining sustained crushing loads of the spar between 200-300 lbf/inch were achieved for potentially limiting occupants loads to around 20 g's. Stroke efficiency of up to 79 percent of the initial spar height under desired sustained crushing loads was obtained which is far greater than the level provided by metal structure. Additionally, a substantial residual spar stiffness was retained after impact, and the flange integrity, which is critical for seat retention, was maintained after crushing of the spars. Author

A93-33911#

COMPOSITE 'EXOSKIN' DOUBLER EXTENDS F-15 VERTICAL TAIL FATIGUE LIFE

MARTY A. FERMAN, SALVATORE L. LIGUORE, CHRIS M. SMITH, and B. J. COLVIN (McDonnell Douglas Aerospace, Saint Louis, MO) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 398-407. refs

(AIAA PAPER 93-1341) Copyright

The fatigue life of the F-15 Vertical Tail was extended by a factor of ten by employing a bond-on composite stiffening doubler, referred to as an 'Exoskin'. This novel approach reduced the tail vibration response created by high angle of attack buffeting forces. The use of this Exoskin eliminated the need of reinforcements of secondary structure which had been considered necessary before the Exoskin was considered. The Exoskin weighs only 8 lb. per aircraft tail and can be readily attached (bonded) by depot level repair methods. Author

A93-33913#

DETERMINATION OF TIRE-WHEEL INTERFACE PRESSURE DISTRIBUTION FOR AIRCRAFT WHEELS

D. J. KIRKNER, B. F. SPENCER, JR., E. E. SCHUDT, S. KANDARPA (Notre Dame Univ., IN), and M. D. CHAWLA (USAF, Flight Dynamics Directorate, Wright-Patterson AFB, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 415-423. Research supported by USAF refs

(AIAA PAPER 93-1343) Copyright

A combined analytical/experimental methodology for obtaining the tire-wheel interface pressure distribution has been developed and previously presented. The principle analytical tool in this methodology is the finite element program ANTWIL which recovers the pressure distribution given a number of experimental strain measurements on the wheel. This paper reports on studies of the F-16 Block 30 and the Block 40 main landing gear wheels to determine the optimal number and location of the strain gages for subsequent experiments. Experiments to be conducted at WPAFB will record strains at the locations specified, and these data will be used to determine the tire-wheel interface pressure distributions. Author

A93-33914*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AN ANALYTICALLY DESIGNED SUBCOMPONENT TEST TO REPRODUCE THE FAILURE OF A COMPOSITE WING BOX BEAM

D. D. DAVIS, JR., GARY L. FARLEY (U.S. Army, Vehicle Structures Directorate, Hampton, VA), DAMODAR R. AMBUR, RANDALL C. DAVIS, MARK J. SHUART, JOHN T. WANG (NASA, Langley Research Center, Hampton, VA), and CHRISTINE G. LOTTS (Analytical Services and Materials, Inc., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 424-435. refs

(AIAA PAPER 93-1344) Copyright

A Stiffener Runout Test Specimen (SRTS) has been analyzed and tested to verify the failure scenario for a large composite wingbox beam subcomponent. The SRTS was taken from an undamaged region of the subcomponent that was similar to the failure region of the boxbeam. Extensive analyses were performed to determine the proper load introduction and constraint conditions required for the SRTS test to simulate the response of the subcomponent. The present paper describes the analyses that led to the design of test fixtures that ensured that the response of the SRTS duplicated the response of the box beam. The results of the SRTS test are described and compared with the analytical predictions. Author

A93-33927*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SOURCES OF HELICOPTER ROTOR HUB INPLANE SHEARS

SESI KOTTAPALLI (NASA, Ames Research Center, Moffett Field, CA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 555-562. refs
(AIAA PAPER 93-1358) Copyright

Sources of helicopter rotor hub inplane shears are identified using simplified equations and the full aeroelastic analysis code, CAMRAD/JA (Johnson, 1988). Analytical results are obtained for an articulated rotor operating at moderate thrust and high airspeed. It is found that the blade chordwise inplane shear, which includes the aerodynamic component, the Coriolis contribution, and the inertial component, and the hub inplane shears are strongly dependent on the out-of-plane response. The sources of helicopter rotor hub inplane shears lie not only in the inplane response but depend on the flap and elastic flatwise responses/modes. AIAA

A93-33928#
EFFECT OF MODELING TECHNIQUES IN THE COUPLED ROTOR-BODY VIBRATION ANALYSIS
SENTHILVEL VELLAICHAMY and INDERJIT CHOPRA (Maryland Univ., College Park) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 563-575. refs
(Contract DAAH04-93-G-0001)
(AIAA PAPER 93-1360) Copyright

The present study is directed towards assessing various mathematical models of rotors and airframe to develop rotor-body coupled vibration analysis. Five rotor models ranging from simple rigid flap model to nonlinear coupled flap-lag-torsion-axial elastic model, and three airframe models ranging from six degree of freedom rigid model to distributed elastic line model are formulated. The rotor-body coupling is achieved through an implicit procedure. For numerical study, an elastic line model of the Huey AH-1G helicopter airframe is coupled to a four bladed soft-inplane hingeless rotor. The study shows simpler blade models over-predict vibration along vertical, pitch, and roll directions and under-predict vibration along longitudinal, lateral, and yaw directions. For proper accounting of rotor-body coupling effects, it is necessary to include a detailed elastic model of airframe. Author (revised)

A93-33954#
ADVANCED TRANSPARENCY DEVELOPMENT FOR USAF AIRCRAFT
MICHAEL P. BOUCHARD (Dayton Univ., OH) and JOSEPH C. DAVISSON (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 800-809. refs
(AIAA PAPER 93-1391)

An engineering approach to advance the state-of-the-art in aircraft transparency design which meet USAF 1995-2000 mission requirements is presented. The approach is based on the following steps: (1) review of available birdstrike test data; (2) design laminates which follow the birdstrike design guidelines of step 1 and provide the flexibility to incorporate technologies which will meet the other design requirements; (3) fabricate and test subscale coupons to screen potential laminates for impact resistance; (4) perform explicit dynamic nonlinear finite element analysis for final analytic bird impact evaluation; (5) select the best designs taking into account all design requirements; (6) fabricate prototype advanced transparencies; and (7) perform full-scale birdstrike, durability, and flight tests. AIAA

A93-33981#
ACOUSTICS DUE TO FLOW-STRUCTURAL INTERACTION AND ITS TRANSMISSION THROUGH A DOUBLE-PANEL IN HIGH-SPEED CRUISING FLIGHT
R. DASH (Acoustics Research and Noise Control, Arlington, TX) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1083-1102. refs
(AIAA PAPER 93-1431) Copyright

A rational model for predicting the effects of high speed flight on the transmission of acoustics through a double panel separated by an intervening airy fluid is presented. Results reveal that, when the cruise flight is within a transonic range, there is a high level of intense acoustics buildup which takes place in both front and rear of the protective double-panelled windscreen of the aircraft. This intense acoustics buildup is attributed to an inevitably high transmission of sound. The proposed analysis describes the structural properties of the two panels including stiffness, damping, and the surface density, multiple impedances, the Mach number of the flight, and the transmission coefficients. AIAA

A93-33987#
DYNAMIC ANALYSIS OF MULTIPLE ROW FUSELAGE STIFFENED STRUCTURES
D. E. HUNTINGTON and C. S. LYRINTZIS (San Diego State Univ., CA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1143-1153. refs
(Contract NSF MSM-90-08953)
(AIAA PAPER 93-1438) Copyright

Frequency response of simplified fuselage structures at moderate to high frequency is obtained by a finite element-decaying wave method, which is a marriage of two previous techniques: a finite element-transfer matrix method and a wave propagation approach. The method is accurate, numerically stable, and relatively fast for a variety of structures, even for long structures at up to 1000 Hz. The structures examined in this work are flat, damped, periodic panel-stringer or panel-stringer-frame configurations, of various lengths, with one, two, or three rows rows, under various boundary conditions. In addition, this work will examine noise transmission from a vibrating skin-stringer-frame structure into a rectangular acoustic enclosure. Author

A93-34014*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
UTILIZATION OF CAD/CAE FOR CONCURRENT DESIGN OF STRUCTURAL AIRCRAFT COMPONENTS
WILLIAM C. KAHN (E-Systems, Inc., Greenville, TX) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 3 Washington American Institute of Aeronautics and Astronautics 1993 p. 1405-1408. Research supported by NASA
(AIAA PAPER 93-1466) Copyright

The feasibility of installing the Stratospheric Observatory for Infrared Astronomy telescope (named SOFIA) into an aircraft for NASA astronomy studies is investigated using CAD/CAE equipment to either design or supply data for every facet of design engineering. The aircraft selected for the platform was a Boeing 747, chosen on the basis of its ability to meet the flight profiles required for the given mission and payload. CAD models of the fuselage of two of the aircraft models studied (747-200 and 747 SP) were developed, and models for the component parts of the telescope and subsystems were developed by the various concurrent engineering groups of the SOFIA program, to determine the requirements for the cavity opening and for design configuration. It is noted that, by developing a plan to use CAD/CAE for concurrent engineering at the beginning of the study, it was possible to produce results in about two-thirds of the time required using traditional methods. AIAA

A93-34021#
BENDING-TORSION FLUTTER OF LINEAR VISCOELASTIC WINGS INCLUDING STRUCTURAL DAMPING
HARRY H. HILTON (Illinois Univ., Urbana) and CURTIS F. VAIL (Johnson Controls, Inc., Milwaukee, WI) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 3 Washington American Institute of Aeronautics and Astronautics 1993 p. 1461-1481. refs
(AIAA PAPER 93-1475) Copyright

An analysis of subsonic and supersonic torsion-bending flutter, including rotary inertia, shear and heating effects, of a time dependent linear viscoelastic two dimensional lifting surface consisting of either a Bernoulli-Euler or a Timoshenko beam is formulated. Complex moduli models for aluminum are characterized as functions of temperature and frequency by fitting Chebyshev polynomials to actual material experimental data. The flutter analysis is carried out in the complex plane and a computerized iterative method for the determination of flutter speeds and frequencies is developed. The influence of viscoelastic material properties (storage and loss moduli), structural damping, temperature, rotary inertia and shear effects is evaluated. The results of the analysis show that in the presence of viscoelastic material damping it is possible to obtain flutter velocities and frequencies which are smaller than undamped elastic ones for the same geometric lifting surface. Author

A93-34044#
APPLICATION OF DIFFERENTIAL QUADRATURE TO THE ANALYSIS OF STATIC AEROELASTIC PHENOMENA
A. G. STRIZ and Y.-W. LOO (Oklahoma Univ., Norman) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 3 Washington American Institute of Aeronautics and Astronautics 1993 p. 1711-1720. refs
(AIAA PAPER 93-1505) Copyright

The numerical technique of differential quadrature is used for the analysis of static aeroelastic phenomena. This method, originally introduced by Bellman and his associates, is applied successfully to the problems of wing divergence and lift distribution for both straight and swept uniform and tapered wings. The equations of equilibrium of the wings together with the boundary conditions are approximated by substituting appropriate weighted sums of the function values at discrete points for the first, second, and third order derivatives, and for integrals. Thus, the bending and torsion differential equations are reduced to sets of linear and eigenvalue equations. The results obtained for all problems under discussion are compared with exact and other numerical solutions where available. Author

A93-34074*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
IN-FLIGHT INVESTIGATION OF A ROTATING CYLINDER-BASED STRUCTURAL EXCITATION SYSTEM FOR FLUTTER TESTING
LURA VERNON (NASA, Flight Research Center, Edwards, CA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 1979-1997. refs
(AIAA PAPER 93-1537) Copyright

A research excitation system was test flown at the NASA Dryden Flight Research Facility on the two-seat F-16XL aircraft. The excitation system is a wingtip-mounted vane with a rotating slotted cylinder at the trailing edge. As the cylinder rotates during flight, the flow is alternately deflected upward and downward through the slot, resulting in a periodic lift force at twice the cylinder's rotational frequency. Flight testing was conducted to determine the excitation system's effectiveness in the subsonic and transonic flight regimes. Primary research objectives were to determine the system's ability to develop adequate force levels to excite the aircraft's structure and to determine the frequency range over which the system could excite structural modes of the aircraft. The results from the exciter were compared with results from atmospheric turbulence excitation at the same flight conditions. The results from the forced excitation were of higher quality and had less variation than the results from atmospheric turbulence. The forced excitation data also invariably yielded higher structural damping values than those from the atmospheric turbulence data. Author

A93-34137#
ACQUIRING TAIL LOAD SPECTRA FROM IN-FLIGHT MEASUREMENTS
P. A. VAN GELDER (National Aerospace Lab., Amsterdam, Netherlands) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2631-2640. Research supported by Netherlands Agency for Aerospace Programs refs
(AIAA PAPER 93-1607) Copyright

A system is described for the recording of tail loads during operational flights, which uses the aircraft's Aircraft Condition Monitoring System in combination with a stand-alone dedicated smart data recorder. Load spectra derived from the measurements are presented. It is shown that the ability to combine load parameters with flight parameters is essential for a proper analysis of the results. AIAA

A93-34158*# National Aeronautics and Space Administration, Washington, DC.
FOREIGN OBJECT IMPACT ASSESSMENT OF A HIGH-MACH ENGINE INLET
D. E. THOMSON (USAF, Turbine Engines Div., Wright-Patterson AFB, OH), W. R. BRAISTED, and R. A. BROCKMAN (Dayton Univ., OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2848-2855. Research supported by National Aero-Space Plane Joint Program Office refs
(AIAA PAPER 93-1630)

The paper presents a foreign-object damage (FOD) assessment of the engine inlet region of a high-velocity aircraft design. Of particular interest is the potential for damage to the active cooling system, which is an integral part of the external skin. A variety of impactors is considered, including hailstones, birds, and rocks of various sizes. An explicit finite element solution, which permits detailed modeling of inelastic material behavior and other nonlinearities, is used for the simulations. The paper also discusses some general aspects of foreign object impact modeling and explicit solution techniques. Author

A93-34173#
EFFICIENT SENSITIVITY ANALYSIS FOR ROTARY-WING AEROMECHANICAL PROBLEMS
ANNE-MARIE SPENCE and ROBERTO CELI (Maryland Univ., College Park) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 3012-3022. refs
(Contract DAAL03-88-C-0002; NSF CDR-88-03012)
(AIAA PAPER 93-1648) Copyright

This paper describes a method for the calculation of the sensitivities of rotating blade root loads and hub loads to changes of blade design parameters using a chain rule differentiation approach. The algorithm exploits features of the formulation of the blade and fuselage equations of motion, and of the solution technique to calculate the sensitivities at a fraction of the cost of an aeroelastic analysis. The mathematical model of the blade

includes nonlinearities due to moderately large elastic deflections and the fuselage is described by nonlinear Euler equations, so that the resulting model is valid for both straight and turning flight. The results indicate that the semi-analytical technique is very accurate and computationally efficient. Author

A93-34222
ACTIVE RIB EXPERIMENT FOR SHAPE CONTROL OF AN ADAPTIVE WING
M. J. ROSSI, F. AUSTIN, and W. VANNOSTRAND (Grumman Corporate Research Center, Bethpage, NY) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 6 Washington American Institute of Aeronautics and Astronautics 1993 p. 3485-3489. refs
(AIAA PAPER 93-1700) Copyright

The previously reported active rib experiment has been modified to include the effects of unknown structural loads on the upper surface, and sensors have been added to enable closed loop control of airfoil shape. The rib is a two-dimensional triangular truss, with attached elastic aluminum upper and lower covers, in which each member has an adjustable length. In this latest experiment the real-time, multi-input, multi-output digital controller alters the 14 lengths to achieve the desired shape without regard to the truss geometry itself. In this way the controller can regulate the shape of the covers regardless of external applied loads. The experimental results demonstrate that the desired shapes can be achieved by closing the loop around actual wing shape. In addition to a description of the experimental design and the theory of operation, this paper discusses the experimental results and compares them with analytical predictions. Author

A93-34223#
SMART STRUCTURES STABILIZED UNSTABLE CONTROL SURFACES
ROBERT G. LOEWY and STEPHEN P. TSENG (Rensselaer Polytechnic Inst., Troy, NY) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 6 Washington American Institute of Aeronautics and Astronautics 1993 p. 3490-3498. refs
(AIAA PAPER 93-1701) Copyright

A two-dimensional wing-aileron-tab model is postulated to simulate a fixed-wing aircraft control system actuated by a 'smart structure' - ie strain - actuated-trailing edge. Wing position is fixed and tab rotation is driven, so that the only degree of freedom is aileron rotation. Linear dynamic analyses are performed to predict the response of such a system to step function commands using state-space versions of 2D unsteady aerodynamic theory. Aileron hinge position, relative to its leading edge, and its rotational spring rates are considered primary design variables. Their influence is studied including combinations in the naturally unstable range, and feedback control is postulated to stabilize the system. Wing aileron parameters intended to be typical of operational aircraft are used to choose smart structure stabilized control surface design variables which are best, based on three deflection, quickest response time, and minimum overshoot. The influences of steady wing angle of attack and flight speed on system performance are also briefly examined. Author

A93-34225
MODAL SENSORS AND ACTUATORS FOR INDIVIDUAL BLADE CONTROL
F. NITZSCHE (DLR, Inst. fuer Aeroelastik, Goettingen, Germany) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 6 Washington American Institute of Aeronautics and Astronautics 1993 p. 3507-3516. refs
(AIAA PAPER 93-1703) Copyright

A general method to incorporate independent modal control to the individual blade control of rotary wings is described. Piezoelectric material may be embedded in the blade structure and conveniently shaped to generate efficient modal filters that present excellent rejection to spillover at the design condition. Closed-loop subsystems may be optimized to improve the damping characteristics of particular blade modes in the rotating frame, aiming at helicopter vibration suppression. Author

A93-34240
AEROELASTIC CHALLENGES FOR A HIGH SPEED CIVIL TRANSPORT
KUMAR G. BHATIA and JIRI WERTHEIMER (Boeing Commercial Airplane Group, Seattle, WA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 6 Washington American Institute of Aeronautics and Astronautics 1993 p. 3663-3682. refs
(AIAA PAPER 93-1478) Copyright

The 1970s SST development programs offer significant lessons in the matter of aeroelastic phenomena for any prospective High Speed Civil Transport (HSCT) design effort. The entire SST design development process was paced by the aeroelastic analysis cycle, which required from 12 to 24 months and estimated significant flutter-related structural weight penalties. Current HSCT design activities involve multidisciplinary analysis and optimization; a knowledge-based system approach is expected to reduce cycle time in the support of preliminary design activities, using aeroelasticity as the integrating discipline. AIAA

A93-34256
THE REBIRTH OF THE TILTROTOR - THE 1992 ALEXANDER A. NIKOLSKY LECTURE
ROBERT R. LYNN (Bell Helicopter Textron, Inc., Fort Worth, TX) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38. no. 1 Jan. 1993 p. 3-16. AHS, Annual Forum and Technology Display, 48th, Washington, June 1992 refs
Copyright

The present development history of tilt-rotor VTOL aircraft gives attention to the critical technology demonstrator program on the basis of whose results the XV-15 proof-of-concept aircraft was developed. The most important figure in XV-3 development was Robert Lichten, who had taken part in the creation of the small Transcendental Model 1G tilt-rotor experimental aircraft. Two- and three-bladed, rigid and semirigid rotors were tested in tilt-wing VTOL operation during the course of XV-3 flight testing; deficiencies noted during USAF/U.S. Army-sponsored flight tests in 1956-1957 were addressed upon the XV-3's turning over to NASA-Ames for additional investigations in 1959. Full-scale tunnel testing of the XV-3 was undertaken by NASA in 1962. AIAA

A93-34262
A MODAL-BASED PROCEDURE FOR EFFICIENTLY PREDICTING LOW VIBRATION ROTOR DESIGNS
WILLIAM H. WELLER and MARK W. DAVIS (United Technologies Research Center, East Hartford, CT) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38. no. 1 Jan. 1993 p. 62-72. AHS, Annual Forum, 46th, Washington, DC, May 21-23, 1990, Proceedings. Vol. 1, p. 403-416. Previously cited in issue 05, p. 647, Accession no. A91-17228 refs
Copyright

A93-34263
FREQUENCY-DOMAIN IDENTIFICATION OF BO 105 DERIVATIVE MODELS WITH ROTOR DEGREES OF FREEDOM
KUANG-HUA FU and JUERGEN KALETKA (DLR, Inst. fuer Flugmechanik, Braunschweig, Germany) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38. no. 1 Jan. 1993 p. 73-83. AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1, p. 3-21. Previously cited in issue 03, p. 308, Accession no. A92-14327 refs
(Contract DFG-SFB-212)
Copyright

A93-34400
OPTIMIZATION OF ENDURANCE PERFORMANCE
GOTTFRIED SACHS (Muenchen, Technische Univ., Munich, Germany) Progress in Aerospace Sciences (ISSN 0376-0421) vol. 29, no. 2 1992 p. 165-191. refs
Copyright

The problem of optimizing the endurance performance of aircraft is considered, with attention given to different types of cruise or flight path control. The types of endurance cruise considered concern classical techniques as well as new methods that are the result of recent research. A discussion of the steady-state endurance cruise covers point performance, integral performance, and endurance performance in holding patterns. The periodic optimal endurance cruise is discussed with reference to optimality conditions, periodic control of variable camber for optimal endurance cruise, and further means for increasing periodic optimal control efficiency. AIAA

A93-34519
C-17 - HIGH-TECH 'LIFTER FROM LONG BEACH
BARRY WHEELER Air International (ISSN 0306-5634) vol. 44, no. 3 March 1993 p. 119-126.
Copyright

The McDonnell Douglas C-17 Globemaster III which is due to give the USAF a much-needed boost to its strategic transport force when it enters full service is described. The C-17 is characterized by a maximum cruising speed of 350 kt; a maximum payload of 172,200 lb; a max take-off weight of 580,000 lb; an overall length of 174 ft; and an overall height of about 55 ft. It is capable of accommodating a flight crew of two and single loadmaster and is the only aircraft to carry the Army's M1 Abrams tank. The C-17 is the first military aircraft with all-digital FBW control system. The pilot has an angle-of-attack limiter system to prevent the aircraft from getting into a stall situation. All control surfaces are managed by the flight control system, the elevators, lower rudder, ailerons, and tailplane with mechanical back-up. AIAA

A93-34848
MACHINERY ARRANGEMENTS FOR SMALL VTOL TRANSPORT AIRCRAFT
D. C. MACPHAIL, A. S. JACKSON, and E. S. MOORE (National Research Council of Canada, Ottawa) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 963 March 1993 p. 101-110. refs
Copyright

Results of some VTOL studies carried out in Canada over a number of years as a supplement to activities in the STOL field are summarized. Several alternative power lift and propulsion arrangments are discussed. Of the alternatives discussed, only one scheme, incorporating transverse axis fans and lightweight gas turbines, is thought to be a potentially satisfactory choice for small rugged transport aircraft with a gross weight up to 30,000 lb. AIAA

A93-34850
SOME CONTRIBUTIONS TO PROPULSION THEORY - FUEL CONSUMPTION FORMULAE AND GENERAL RANGE EQUATION
C. L. BORE (British Aerospace, PLC, Kingston, United Kingdom) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 963 March 1993 p. 118-120. refs
Copyright

A simple formula for the fuel consumption rates of jet engines is presented which is valid for all altitudes and speeds. A general range equation is then derived which covers all altitude and thrust levels, and it is shown that the Brequet equation is a special case of this equation. A ferrying capacity formula is also proposed which provides a convenient way to estimate the effects of weight reduction and changes in the lift/drag ratio and engine fuel consumption. AIAA

A93-35630
NONLINEAR LARGE AMPLITUDE VIBRATION OF COMPOSITE HELICOPTER BLADE AT LARGE STATIC DEFLECTION
TAEHYOUN KIM and JOHN DUGUNDJI (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 938-946. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3, p. 2071-2081. Previously cited in issue 12, p. 1913, Accession no. A91-32035 refs
(Contract DAAL03-87-K-0024)
Copyright

A93-35676
FLIGHT-VEHICLE DRIVES (2ND REVISED AND ENLARGED EDITION) [ELEKTROPRIVOD LETATEL'NYKH APPARATOV /2ND REVISED AND ENLARGED EDITION/]
VITALII A. POLKOVNIKOV, BORIS I. PETROV, BORIS N. POPOV, A. V. SERGEEV, and A. N. SPERANSKII Moscow Izdatel'stvo Mashinostroenie 1990 352 p. In Russian. refs
(ISBN 5-217-00802-4) Copyright

The fundamentals of the theory and analysis of the electric servo systems of flight vehicles are discussed. The static, dynamic, and energy characteristics of servo systems with different types of actuating mechanisms (e.g., ac and dc motors, electromagnetic clutches, and mechanical variable-speed drives) are examined in relation to different methods of control; the limiting dynamic possibilities of servo systems are evaluated. Examples of different schemes of electric servo drives employing various types of actuating mechanisms and different control methods are presented. AIAA

N93-24739# Kansas Univ., Lawrence. Flight Research Lab.
GENERAL AVIATION AIRCRAFT: NORMAL ACCELERATION DATA ANALYSIS AND COLLECTION PROJECT Final Report
JAMES E. LOCKE, HOWARD W. SMITH, EDWARD A. GABRIEL, and THOMAS DEFLORE Feb. 1993 341 p Prepared in cooperation with Wichita State Univ., KS
(DOT/FAA/CT-91/20; KU-FRL-926-1) Avail: CASI HC A15/MF A03

This report contains the analysis and condensation of repeated flight loads obtained from 77 airplanes that participated in the NASA Velocity Gravity Height (VGH) General Aviation Program. In addition, the load spectra for 98 airplanes in the NASA VGH data base are presented as plotted and tabulated data. Curve fit equations are listed for the original data and for extrapolation, which was used in the statistical analysis. Airspeed, normal load factor, and altitude were recorded continuously during flight. The load factor data were separated into gust and maneuver normal accelerations. The reduced data are presented as cumulative number of occurrences per nautical mile versus acceleration fraction (incremental normal acceleration divided by incremental limit load factor). For statistical analysis, the airplanes were grouped into seven single and twin-engine operational usage groups. The mean (weighted by flight time), weighted mean--plus one, two, and three standard deviation spectra, and the 90 percent probability/95 percent confidence spectra were determined for each operational usage group and for several of the groups combined. An estimate of the scatter associated with groups having small sample size was determined by computing a pooled variance and pooled standard deviation. The resulting load spectra are to be used for wing fatigue test or safe-life estimation. The Federal Aviation Administration's plans for further study using the results of this report are discussed. The final objective of this effort is to produce a revised fatigue evaluation report for small and commuter airplane certification under Part 23 of the Federal Aviation Regulations. Author (revised)

N93-24768 Stanford Univ., CA.
AERODYNAMIC DESIGN AND SYNTHESIS OF THE OBLIQUE FLYING WING SUPERSONIC TRANSPORT Ph.D. Thesis
ALEXANDER JACOBUS M. VANDERVELDEN 1992 310 p
Avail: Univ. Microfilms Order No. DA9234183

The performance of an oblique flying wing supersonic transport

was investigated in this study and its economics were compared with those of conventional transports. Aerodynamics, structures, propulsion, environmental impact, (sonic boom, ozone, noise) and economy were analyzed for a given mission, subject to environmental constraints from Mach 0.8 to Mach 2.0. Twenty variables represented the aircraft geometry, engine characteristics, and mission. These variables were optimized simultaneously for the aircraft families as a function of Mach number, payload, and range. The globally optimized oblique flying wing was designed in detail with a new design method and analyzed with CFD codes. The wing did not only achieve the low drag predicted by the synthesis method but was trimmable over its entire flight envelope. Results showed oblique flying wings with payloads over 400 passengers to be superior for all missions considered. At supersonic speeds operating costs half that of delta-wing transports were achieved. The improvements were attributable to the higher lift-to-drag ratios as well as the beneficial effect of span loading on the structural weight. Dissert. Abstr.

N93-25162*# Arizona State Univ., Tempe. Coll. of Engineering and Applied Sciences.

GENERIC HYPERSONIC VEHICLE PERFORMANCE MODEL Interim Task Report

FRANK R. CHAVEZ and DAVID K. SCHMIDT Apr. 1993 32 p (Contract NAG1-1341)

(NASA-CR-192953; NAS 1.26:192953; ARC-93-3) Avail: CASI HC A03/MF A01

An integrated computational model of a generic hypersonic vehicle was developed for the purpose of determining the vehicle's performance characteristics, which include the lift, drag, thrust, and moment acting on the vehicle at specified altitude, flight condition, and vehicular configuration. The lift, drag, thrust, and moment are developed for the body fixed coordinate system. These forces and moments arise from both aerodynamic and propulsive sources. SCRAMjet engine performance characteristics, such as fuel flow rate, can also be determined. The vehicle is assumed to be a lifting body with a single aerodynamic control surface. The body shape and control surface location are arbitrary and must be defined. The aerodynamics are calculated using either 2-dimensional Newtonian or modified Newtonian theory and approximate high-Mach-number Prandtl-Meyer expansion theory. Skin-friction drag was also accounted for. The skin-friction drag coefficient is a function of the freestream Mach number. The data for the skin-friction drag coefficient values were taken from NASA Technical Memorandum 102610. The modeling of the vehicle's SCRAMjet engine is based on quasi 1-dimensional gas dynamics for the engine diffuser, nozzle, and the combustor with heat addition. The engine has three variable inputs for control: the engine inlet diffuser area ratio, the total temperature rise through the combustor due to combustion of the fuel, and the engine internal expansion nozzle area ratio. The pressure distribution over the vehicle's lower aft body surface, which acts as an external nozzle, is calculated using a combination of quasi 1-dimensional gas dynamic theory and Newtonian or modified Newtonian theory. The exhaust plume shape is determined by matching the pressure inside the plume, calculated from the gas dynamic equations, with the freestream pressure, calculated from Newtonian or Modified Newtonian theory. In this manner, the pressure distribution along the vehicle after body expansion surface is then determined. The aerodynamic modeling, the engine modeling, and the exhaust plume analysis are described in more detail. A description of the computer code used to perform the above calculations is given and an input/output example is then given. The computer code is available on a Macintosh floppy disk. Author (revised)

N93-25279 Virginia Polytechnic Inst. and State Univ., Blacksburg.

INTEGRATED AERODYNAMIC-STRUCTURAL WING DESIGN OPTIMIZATION Ph.D. Thesis

ERIC ROBERT UNGER 1992 101 p

Avail: Univ. Microfilms Order No. DA9220650

Several procedures for the simultaneous aerodynamic-structural design optimization of aircraft wings are investigated. These procedures include efficient methods for optimization and sensitivity calculations that are applied to two specific design examples. The first is a subsonic transport aircraft with a composite forward-swept wing. The aerodynamic modeling for this case is provided by vortex-lattice theory and the structural model initially utilizes finite-element analyses. Even with efficient sensitivity methods, the approximate optimization problem still requires a large computational effort. To reduce this cost, a variable-complexity model for the structural analyses is introduced. First, an algebraic equation model for wing weight is used in the optimization procedure to obtain an aerodynamic design that approximately accounts for the effects of wing geometry on wing weight. Then this design is refined by simultaneous aerodynamic-structural optimization based on the finite-element analysis. The net effect of this dual structural model is a substantial reduction in optimization costs. The second example is the wing design of a supersonic High-Speed Civil Transport (HSCT). For this case, the simple wing-weight equations for structures are retained. For the aerodynamics, a variable-complexity model was introduced with the complex models provided by volumetric wave drag analysis and panel methods. In addition, simple algebraic models for wave and drag use to lift provide inexpensive approximations during most of the optimization cycles. With the minimization of the costly complex sensitivity calculations, a reduction in optimization costs is realized. Dissert. Abstr.

N93-25408 Cranfield Inst. of Tech., Bedford (England).

A PRELIMINARY SIZING METHOD FOR UNMANNED AIRCRAFT USING MULTI-VARIATE OPTIMISATION Ph.D. Thesis

A. TURNBULL 1990 383 p

Avail: Univ. Microfilms Order No. BRDX98006

The project was carried out, initially, under sponsorship from RAE Farnborough, the object being to obtain a design 'tool' to aid the initial project design work done on turbojet propelled unmanned aircraft. Hence, a sizing method for any unmanned air vehicle configuration with turbojet propulsion, using methods compatible with RAE multi-variate optimization techniques, evolved. The scope of the research was extended to include both turbojet and piston propulsion systems. The range of vehicle configuration is wide, with a choice of internally or externally mounted turbojet engines, forward tractor type or rear pusher type piston engines; conventional flying surfaces or twin boom, twin fin type configurations. The internal fuselage layout is user-defined and has numerous possibilities. The aircraft synthesis uses standard mass and drag estimations, where applicable, for the airframe and vehicle systems, such as fuselage, wing, propulsion, electrics, and recovery systems. The synthesized vehicle is assumed to fly a user-specified mission profile with the performance and fuel requirements for each leg of the sortie being calculated. The mission profile can consist of a maximum of seven legs: climb, cruise, loiter, acceleration, high speed dash, maneuver, and return. The total fuel consumption, along with the fuel reserves are calculated to give the total overall vehicle mass. The design synthesis can be used as a stand-alone program or with the optimization package, RQPMIN. During the latter the vehicle mass is optimized with respect to specified configuration parameters while having to satisfy user-specified constraints (both geometric and performance related). A detailed output is produced, giving the initial and final vehicle configurations; including component masses, total geometric values and mission performance details. The optimization program details, such as constraint and independent variable values are also given. Dissert. Abstr.

N93-25486 Georgia Inst. of Tech., Atlanta.

APPLICATION OF FINITE-STATE INFLOW TO FLAP-LAG-TORSION DAMPING IN HOVER Ph.D. Thesis

DONIZETI DEANDRADE 1992 204 p

Avail: Univ. Microfilms Order No. DA9303157

The aeroelastic stability of helicopter rotors in hovering flight is investigated by a coupled set of generalized dynamic wake equations and hybrid equations of motion for an elastic blade cantilevered in bending and having a torsional root spring to model

pitch-link flexibility. The generalized dynamic wake model employed is based on an induced flow distribution expanded in a set of harmonic and radial shape functions, including undetermined time dependent coefficients as aerodynamic states. The flow is described by a system of first-order, ordinary differential equations in time, for which the pressure distribution at the rotor disk is expressed as a summation of the discrete loadings on each blade, accounting simultaneously for a finite number of blades and overall rotor effects. The nonlinear blade equations are simplified by the assumption of uniform blade mass and stiffness; and then they are reduced to nonlinear differential equations by Galerkin's method. Inflow and blade equations are matched in a way to establish a standard eigen-analysis for the stability of small motions about blade equilibrium and steady-state inflow. The coefficient matrices in the eigenproblem depend on the numerical solution of blade equilibrium and steady-state inflow nonlinear algebraic equations. The model has been applied to a two-bladed, untwisted, stiff inplane hingeless small scale rotor with torsionally soft blades, including a blade root offset, and hub designed to permit variation in precone, blade droop, pitch control stiffness, and blade pitch angle. Numerical results show that three-dimensional tip relief effects within the nonuniform steady-state inflow are significant to predict steady-state aerodynamic loads and blade deflections. The eigenvalue results confirmed the importance of unsteady, three-dimensional aerodynamics in predicting lead-lag damping, by means of correlations with unsteady three-dimensional panel theory and with experiments. Eigenvector analysis correlations reinforced qualitative and quantitative shortcomings associated with quasi-steady two-dimensional aerodynamic theory for aeroelastic applications in hover. Overall results from this research set the present finite-state methodology as a suitable tool to handle helicopter integrated dynamics. This is chiefly due to elimination of time-marching and moving block analysis inherent to previous approaches to the same problem, implying in substantial savings in computer memory and time, with no essential loss of accuracy. Dissert. Abstr.

N93-25526 Stanford Univ., CA.
STRUCTURAL AND AERODYNAMIC OPTIMIZATION OF JOINED-WING AIRCRAFT Ph.D. Thesis
JOHN WALDEMAR GALLMAN 1992 258 p
Avail: Univ. Microfilms Order No. DA9234097

The joined wing is an innovative aircraft configuration with a rear wing that is attached near the top of the vertical tail and sweeps forward to join the trailing edge of the forward wing. This study evaluates the performance of joined-wing aircraft and demonstrates the use of numerical optimization in aircraft design. Initially, a parametric design study that considered a single cruise condition indicated an 11 percent savings in trimmed drag for a joined-wing with the same lifting surface area and 23 percent longer wing span than a conventional configuration. These results encouraged further study of the joined-wing concept and motivated the development of a computer program that uses numerical optimization to design both joined-wing and conventional configurations. This design program uses a vortex-lattice model of all aircraft components to calculate aerodynamic forces and a beam model of the lifting-surface structure to calculate wing and tail weight. Weight estimation depends on a fully-stressed design algorithm that includes a constraint on buckling and a correlation with a statistically based method for total lifting-surface weight. This fully-stressed sizing routine produced joined-wing structures that are nearly identical to minimum-weight structures designed using numerical optimization. A variety of 'optimum' joined-wing and conventional aircraft designs were compared on the basis of direct operating cost, gross weight, and cruise drag. Maximum lift and tail buckling were identified as critical joined-wing design issues. The addition of a buckling constraint was shown to decrease the optimum joined-wing space by 8 percent and increase direct operating cost by 4 percent. Although aeroelasticity and dynamic stability were neglected during the design study, separate analyses showed that the optimum configurations have sufficient damping for good handling qualities and flutter speeds that are well above the design dive speed. The most promising joined-wing designs have a joint location at about 70 percent of the wing semispan, a fuel tank in the tail to trim, and a flap spanning 70 percent of the wing. These designs are shown to cost 3 percent more to operate than a conventional configuration designed for the same medium-range mission. Dissert. Abstr.

N93-25530 Maryland Univ., College Park.
AEROELASTIC RESPONSE AND AEROMECHANICAL STABILITY OF HELICOPTERS WITH ELASTICALLY COUPLED COMPOSITE ROTOR BLADES Ph.D. Thesis
EDWARD C. SMITH 1992 453 p
Avail: Univ. Microfilms Order No. DA9304398

A comprehensive formulation was developed to study the effects of elastically coupled composite helicopter rotor blades on aeroelastic response, blade and hub loads, rotor aeroelastic stability, and rotor-fuselage aeromechanical stability. Both hover and forward flight conditions are addressed, and the aeromechanical stability analysis includes both air and ground resonance phenomenon. A new analysis was formulated to model the laminated composite box-beam blade spar. The box-beam analysis includes the nonclassical structural effects of transverse shear, torsion-related out-of-plane warping, and two-dimensional ply elasticity. Elastic couplings are introduced through the anisotropy of the plies in the composite spar. For the aeroelastic and aeromechanical analysis, the blade is idealized as an elastic beam undergoing moderate deflections in flap and lag bending, elastic torsion, elastic axial deformation, and flap and lag transverse shear. A nineteen d.o.f. shear flexible beam element is introduced for the composite rotor blades. The structural model is validated by correlation with experimental data and finite element solutions for static deflections of elastically coupled graphite-epoxy composite box-beams. The quantitative importance of the nonclassical structural effects is also investigated. The free vibration analysis is validated by correlation with experimental data and finite element results for the in vacuo rotating natural frequencies of the composite box-beams. The aeromechanical stability analysis is correlated against experimental data for a model hingeless rotor-body configuration. Results indicate that elastic couplings introduced through the composite blade spar have a powerful effect on both shaft-fixed blade stability and rotor-body aeromechanical stability. The torsional response is also significantly affected by the composite couplings. Influence of composite couplings on blade and hub loads was measurable, but less pronounced. Dissert. Abstr.

N93-25538 Georgia Inst. of Tech., Atlanta.
AN INTEGRATED FINITE-STATE MODEL FOR ROTOR DEFORMATION, NONLINEAR AIRLOADS, INFLOW, AND TRIM Ph.D. Thesis
WALTER MARTIN STUMPF 1992 236 p
Avail: Univ. Microfilms Order No. DA9303147

Existing models for forward flight rotor aeroelastic loads suffer from a number of deficiencies. These models often use crude aerodynamics coupled with sophisticated blade equations, require excessive computation, contain modules that must be solved sequentially rather than simultaneously, or contain hidden states or a large number of states. The aeroelastic model described here addresses these deficiencies. It is a time-domain, state-space aeroelastic model of a rotor in forward flight. The model computes trim, airloads, rotor shaft loads and the instantaneous inflow distribution. All components of the model are expressed as ordinary differential equations, which are solved by integrating the system in time until a periodic solution is reached. The states have physical significance and, since there are a finite number of them, Floquet theory may be applied. The aerodynamic and structural models are of a comparable level of sophistication and are strongly coupled. The section airloads are described by a classical thin airfoil theory, which treats the wake contribution as a external forcing function. The airloads are modified to reflect the presence of dynamic stall using the semi-empirical ONERA dynamic stall model. The wake contribution is computed using the Peters generalized dynamic inflow theory, which is based on a series solution of the potential-flow equation. The Hodges and Dowell elastic blade

equations are approximated using the Galerkin-Ritz method. Trim is found using an automatic controller, also written as a set of ordinary-differential equations. When the number of shape functions and aerodynamic control points are chosen to include dynamics up to a frequency of four per rev., the model including inflow, stall, blade deformations and trim, is defined by about 50 state variables. A trimmed solution requires between 10 and 40 revolutions to trim, and costing about four minutes of CPU time per ten revolutions (on a VAX 6440). The model response has been validated using flight test data from the SA349 helicopter. The blade motions and aerodynamic normal forces predicted by the model agreed fairly well with the measured values, but the pitching moment predictions were less successful.

Dissert. Abstr.

N93-25552# Old Dominion Univ., Norfolk, VA.
A COMPUTATIONAL AERODYNAMIC DESIGN OPTIMIZATION METHOD USING SENSITIVITY ANALYSIS Ph.D. Thesis
MOHAMED EL-AMIN ELESHAKY 1992 235 p
Avail: Univ. Microfilms Order No. DA9230207

A new and efficient procedure for aerodynamic shape optimization is presented. The salient lineaments of this procedure are: (1) using a discrete sensitivity analysis approach to determine analytically the aerodynamic sensitivity coefficients; (2) obtaining the flowfield solution either by a computational fluid dynamics (CFD) analysis or, alternatively, by a flowfield extrapolation method which is based on a truncated Taylor's series; (3) defining the aerodynamic shape in such a way that it is not restricted to any class of surfaces and the optimizer automatically shapes the aerodynamic configuration to any arbitrary geometry; and (4) requiring no expertise other than that needed for formulating the optimization problem in question. This procedure is successfully demonstrated on different aerodynamic optimization problems. In one of the optimization problems, the ramp shape of a scram jet nozzle-afterbody configuration is optimized to yield a maximum thrust force coefficient. However, prior to its design optimization, a CFD capability for the mixing of two-dimensional, viscous, multispecies flows has been developed in order to gain a detailed understanding of the complex flowfield features of the scram jet nozzle-afterbody configuration. It is shown that heavier exhaust mixture (simulated by a Freon-Argon mixture) undergoes gas dynamic expansion at a smaller rate than does lighter 'air' exhaust flow. In the sensitivity analysis approach, both Euler and thin-layer Navier-Stokes equations are used. Their discretized equations are solved using an implicit, upwind-biased, finite-volume scheme. The van Leer flux-vector splitting is used in the discretization of the pressure and convective terms. The direct and iterative solution methods, which are deemed most applicable to the large linear systems of algebraic equations arising in the sensitivity approach, are investigated with regards to their accuracies, computational time, and computer memory requirements. These methods are shown to be feasible only for small two-dimensional problems. Due to the prohibitively high memory requirements, they become impractical for large two-dimensional problems and inapplicable for any of the three-dimensional problems. To alleviate this limitation, a new scheme based on domain decomposition principles has been developed and is called the Sensitivity Analysis Domain-Decomposition (SADD) scheme. Dissert. Abstr.

N93-25670*# Iowa State Univ. of Science and Technology, Ames. Dept. of Aerospace Engineering and Engineering Mechanics.
TRAJECTORY OPTIMIZATION FOR THE NATIONAL AEROSPACE PLANE Semiannual Report, 13 Jun. - 12 Dec. 1992
PING LU Jan. 1993 10 p
(Contract NAG1-1255)
(NASA-CR-192954; NAS 1.26:192954) Avail: CASI HC A02/MF A01

While continuing the application of the inverse dynamics approach in obtaining the optimal numerical solutions, the research during the past six months has been focused on the formulation and derivation of closed-form solutions for constrained hypersonic flight trajectories. Since it was found in the research of the first year that a dominant portion of the optimal ascent trajectory of the aerospace plane is constrained by dynamic pressure and heating constraints, the application of the analytical solutions significantly enhances the efficiency in trajectory optimization, provides a better insight to understanding of the trajectory and conceivably has great potential in guidance of the vehicle. Work of this period has been reported in four technical papers. Two of the papers were presented in the AIAA Guidance, Navigation, and Control Conference (Hilton Head, SC, August, 1992) and Fourth International Aerospace Planes Conference (Orlando, FL, December, 1992). The other two papers have been accepted for publication by Journal of Guidance, Control, and Dynamics, and will appear in 1993. This report briefly summarizes the work done in the past six months and work currently underway.

Derived from text

N93-25692 Cranfield Inst. of Tech., Bedford (England).
AN APPROACH TO CONFIGURATION DESIGN SYNTHESIS OF SUBSONIC TRANSPORT AIRCRAFT USING ARTIFICIAL INTELLIGENCE TECHNIQUES Ph.D. Thesis
H. M. PASARIBU 1991 272 p
Avail: Univ. Microfilms Order No. BRDX97987

This thesis outlines a computer system developed to tackle the configuration design synthesis of subsonic transport aircraft. The system provides an interactive design environment which combines the reasoning process of the aircraft configuration definition and the numerical analyses that lie behind the reasoning. The system applies artificial intelligence (AI) techniques to the configuration analysis. This gives the system the capability to reason with the configuration choices. The system is built in modules, with each module being clearly separated to deal with a complete analysis in a specific aspect of design. The integration of the modules is done through an intelligent interface and a common database. The interface also incorporates AI techniques in deciding the sequence of execution of the modules and the processing of the input/output data for a particular module. The interface permits the sharing of information among the modules and supports modularity and flexibility of the system for future development. Since each module is independent, it can be easily modified or replaced without disturbing the balance of the system. An extensive library of application programs is included in the engineering analysis module which enable detailed analysis to be performed. The system is equipped with a simplified database management and a special purpose graphics module which is extensively used for the presentation of the output. The system has been validated and tested. It can handle both propeller driven and jet engined aircraft. An example of the case studies is presented. The improvement of the system for future development is also considered. These include the extension of the knowledge base for dealing with problems in other modules, the enhancement of the application programs in the engineering module, and a possible interface with an established Computer Aided Drafting (CAD) system. Dissert. Abstr.

N93-25701 Rensselaer Polytechnic Inst., Troy, NY.
DESIGN AND ANALYSIS OF CURVED COMPOSITE COMPONENTS FOR ROTORCRAFT FUSELAGE FRAMES Ph.D. Thesis
ANN W. PECK 1992 238 p
Avail: Univ. Microfilms Order No. DA9302698

An investigation in the design and analysis of curved composite components for rotorcraft fuselage frames was conducted. Using a strength of material based approach, analytical expressions were developed to predict the flange and web stress resultants in curved beams made of anisotropic materials. Two parameters, which include flange and web geometric and material stiffness effects, have been identified that characterize the flange stress redistributions due to curling. After validation of the analytical solutions using a finite element model, a parameter study was performed to examine the effects material anisotropy and cross-sectional configuration have on the flange curving behavior. It has been found that the flange and web laminates have a

significant effect on the internal stress distributions. Reducing flange curling reduces the amount of flange axial load redistribution but increases the maximum curling moment. An increase of the web bending stiffness increases the overall bending stiffness and flange efficiency, but also increases the flange root curling moment and the web bending moment in the C- and box cross-sectonal configurations. At some point, an increase in the web bending stiffness diminishes the overall load carrying capability as the web becomes the critical element. It appears to be difficult to utilize material anisotropy to improve the overall load carrying capability. Formal optimization techniques were used to investigate the maximum load carrying capability of curved composite beams. The overall driving design factor was found to be flange curling. To maximize overall load carrying capability in curved composite beams with fixed-length flanges, the overall bending stiffness is maximized by minimizing web thicknesses and moving structural material out towards the flanges and flange curling minimized by minimizing flange lengths, increasing flange thicknesses, minimizing web thicknesses in the C- and box beams, placing predominantly 0 degree and 90 degree fibers in the flange laminates with 0 degree fibers on the interior and 90 degree fibers on the outside, and placing predominantly 0 degree fibers in the web laminates of the C- and box configurations. The optimum cross-sectional configuration is dependent on chosen quantities, such as flange lengths, beam mass. For fixed-length flanges, no clear optimum cross-section was found. Dissert. Abstr.

N93-25704 Cranfield Inst. of Tech., Bedford (England).
ASTOVL COMBAT AIRCRAFT DESIGN SYNTHESIS AND OPTIMIZATION Ph.D. Thesis
N. KEHAYAS 1992 293 p
Avail: Univ. Microfilms Order No. BRDX98001

This thesis presents the development of a Baseline Configuration for an Advanced Short Take-Off and Vertical Landing (ASTOVL) Combat Aircraft, the Design Synthesis and coding of this Baseline Configuration (Code VERTI), the interfacing of the Design Synthesis Code VERTI with the Optimizer code RQPMIN and the optimization of the Baseline Configuration. The background and the objectives of this Research Program are initially examined. The evaluation of the ASTOVL Combat Aircraft Baseline Configuration is then described, including all the problems, assumptions, choices and compromises that led to the specific configuration. The development of the Design Synthesis and the Code VERTI then follow, where the methodology used, the techniques adopted and the code operation are explained. A full description of the Design Synthesis is included as an appendix. Finally, the interfacing of Code VERTI with the optimizer RQPMIN and the optimization of the Baseline Configuration are presented. The problems and difficulties of the RQPMIN operation are thoroughly discussed. The RQPMIN-VERTI Code is used to optimize the initial Baseline Configuration and an optimization example is provided in appendix form. The optimized Baseline Configuration is partly validated against two ASTOVL combat aircraft designs. In addition to the optimization with the aircraft empty mass as objective function, a search for a better objective function is attempted. Dissert. Abstr.

N93-25719 Rensselaer Polytechnic Inst., Troy, NY.
STRUCTURAL DYNAMIC ANALYSIS OF BEARINGLESS ROTOR BLADE Ph.D. Thesis
WUYING CHIANG 1992 261 p
Avail: Univ. Microfilms Order No. DA9236209

Conventional articulated helicopter rotor systems typically have mechanical hinges, dampers and bearings in the hub to relieve high blade root moments and to ensure dynamic stability. This hardware operates in a high stress field and experiences large cyclic and centrifugal loads. These devices require continuous inspection and frequent maintenance. In addition, they can significantly degrade the reliability of the rotor system. In order to improve helicopter reliability, reduce maintenance, and potentially improve rotor hub aerodynamic characteristics, the helicopter researchers have developed the hingeless and bearingless rotor by taking advantage of recent advancements in materials technology. The unique structural features of bearingless rotors calls for the development of design and modeling methodologies for laminated composite flex-structures. Indeed, the flex-structure should be flexible enough to replace the flap, lead-lag, and feathering bearings, while maintaining high strength and stiffness in the axial direction. Laminated composite materials are a material of choice for such an application. Chordwise deformations, transitional zones between different cross-sections and localized compressive stresses are all likely to be present in the flex-structure, rendering the validity of a beam model questionable. In this research an anisotropic shallow shell model is developed that accommodates transverse shearing deformations and arbitrarily large displacements and rotations. However, strains are assumed to remain small. Two kinematic models are developed in this research: the first model uses two rotation parameters to locate the direction of the normal to the shell's mid-plane while the second one uses a rotation tensor which is composed of three parameters. The latter model, which has an in-plane rotation degree-of-freedom, allows for an automatic compatibility of the shell model with other three-dimensional structural models. A shell model is validated by comparing its predictions with several benchmark problems which include static and dynamic, linear and nonlinear, as well as isotropic and anisotropic conditions. The performance of the in-plane rotation degree-of-freedom of the shell model is tested also by solving some special configurations. In actual helicopter rotor blade problems, the shell model of the flex-structure is shown to give very different results when compared to beam models. The lead-lag and torsion modes are strongly affected, whereas flapping modes seem to be less affected. A study was also carried out to simulate a tail rotor system; the pitch actuator force is found to vary significantly when shell or beam models are used. Dissert. Abstr.

N93-25733# Air Force Occupational Measurement Center, Randolph AFB, TX.
AIRCRAFT ELECTRICAL AND ENVIRONMENTAL SYSTEMS, AFSCS 452X5, 454X5, AND 454X6
Jan. 1993 71 p
(AD-A261213) Avail: CASI HC A04/MF A01

This is a report of an occupational survey of the Electrical and Environmental Systems career ladders conducted by the Occupational Analysis Flight, USAFOMS. The Headquarters Air Training Command (ATC) Aircraft/ Munitions maintenance Training Division requested this survey to project, plan, and develop Career Development Courses (CDC), STS's, and training for these career ladders due to the Rivet Workforce restructing of AFSC 423X0--Aircraft Electrical Systems and AFSC 423X1--Aircraft Environmental Systems. The last surveys pertaining to these career ladders were published in Feb. 1984 (AFSC 423X1) and Feb. 1985 (AFSC 423X0). The merger of the Electrical and Environmental, Strategic Electrical and Environmental, and Airlift Electrical and Environmental. Members of all these career ladders participated in this survey. In Jun. 1992, a U and TW decided to merge the three ladders into a single Aircraft Electrical and Environmental Systems career ladder (AFSC 452X5), effective Apr. 1993. DTIC

N93-25933# Naval Aerospace Medical Research Lab., Pensacola, FL.
PERFORMANCE-BASED TESTING AND SUCCESS IN NAVAL ADVANCED FLIGHT TRAINING Interim Report
DAVID J. BLOWER Nov. 1992 35 p
(Contract NR PROJ. M00-96)
(AD-A260838; NAMRL-1378) Avail: CASI HC A03/MF A01

Roughly 5 percent of student naval aviators fail the advanced phase of flight training. At this stage of training, the Navy has spent between $300,000 and $1,000,000 per student. Any reduction in this attrition rate through prior screening would be of great economic benefit to the Navy. Computer-based performance tests developed at the Naval Aerospace Medical Research Laboratory were assessed to determine whether they could augment the present medical screening standards and thereby help identify potential failures in advanced flight training. A weak statistical

relationship exists between a dual-task performance test, accession source, college major, an aptitude test, and success in advanced flight training. Discriminant analysis was employed to find a linear composite score of these variables that could be used to classify a student as a probable pass or fail in advanced flight training. For example, the model presented in this report reduced failures by 50 percent at the cost of rejecting roughly 20 percent of those students who eventually passed. A Bayesian analysis of the success rate parameter showed that this particular model significantly improved the present selection system. DTIC

N93-25949# Aerospace Medical Research Labs., Wright-Patterson AFB, OH. Human Engineering Div.
INFORMATION REQUIREMENTS ANALYSES FOR TRANSATMOSPHERIC VEHICLES Final Report, Jul. 1991 - Jun. 1992
GILBERT G. KUPERMAN Jun. 1992 218 p
(Contract F33615-89-C-0532)
(AD-A261189; AL-TR-1992-0082) Avail: CASI HC A10/MF A03

An information requirements analysis was performed as the initial step in the design of crew system concept for future transatmospheric vehicles (TAVs). A knowledge acquisition, synthesis, and representation process was conducted. A baseline system description was prepared. Concept Maps were generated. A mission event sequence was developed. System architecture depictions were generated. Measures of effectiveness and performance were documented. DTIC

N93-26444# Naval Postgraduate School, Monterey, CA.
AEW AIRCRAFT DESIGN M.S. Thesis
MICHAEL J. WAGNER Dec. 1992 114 p
(AD-A261800) Avail: CASI HC A06/MF A02

The aging E-2C fleet is expected to be retired by the year 2015. In order to provide Airborne Early Warning (AEW) for the battle group during the transitional years and beyond, the design of a replacement aircraft must begin soon. In order to conform with present day economic realities, one possible configuration is a new airframe using the radar system and rotodome which currently operates on the E-2C. Other likely requirements for a new AEW aircraft includes a high-speed dash (M=0.7-0.85) capability, an extended mission time (up to 7.5 hours), turbofan engines, and an aircrew ejection system. The results of this design effort includes an investigation of a possible configuration and the aerodynamics involved. Performance, stability and control characteristics are also discussed briefly. Finally, a qualitative analysis of the use of the E-2C's radar system on a new airframe will be presented. DTIC

N93-26553*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC AEROELASTIC INSTABILITY RESULTS FOR A NASP-LIKE WING MODEL
STANLEY R. COLE, JAMES R. FLORANCE, LEE B. THOMASON, CHARLES V. SPAIN (Lockheed Engineering and Sciences Co., Hampton, VA.), and ELLEN P. BULLOCK (Lockheed Engineering and Sciences Co., Hampton, VA.) Apr. 1993 12 p Presented at the AIAA 34th SDM Conference, Hampton, VA, 19-23 Apr. 1993
(Contract RTOP 763-23-41)
(NASA-TM-107739; NAS 1.15:107739) Avail: CASI HC A03/MF A01

An experimental study and an analytical study have been conducted to examine static divergence for hypersonic-vehicle wing models at supersonic conditions. A supersonic test in the Langley Unitary Plan Wind Tunnel facility was conducted for two wind-tunnel models. These models were nearly identical with the exception of airfoil shape. One model had a four-percent maximum thickness airfoil and the other model had an eight-percent maximum thickness airfoil. The wing models had low-aspect ratios and highly swept leading edges. The all-movable wing models were supported by a single-pivot mechanism along the wing root. For both of the wind-tunnel models, configuration changes could be made in the wing-pivot location along the wing root and in the wing-pivot pitch stiffness. Three divergence conditions were measured for the four-percent thick airfoil model in the Mach number range of 2.6 to 3.6 and one divergence condition was measured for the eight-percent thick airfoil model at a Mach number of 2.9. Analytical divergence calculations were made for comparison with experimental results and to evaluate the parametric effects of wing-pivot stiffness, wing-pivot location, and airfoil thickness variations. These analyses showed that decreasing airfoil thickness, moving the wing-pivot location upstream, or increasing the pitch-pivot stiffness have the beneficial effect of increasing the divergence dynamic pressures. The calculations predicted the trend of experimental divergence dynamic pressure with Mach number accurately; however, the calculations were approximately 25 percent conservative with respect to dynamic pressure. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A93-34819
MINIATURE DISPLAY TECHNOLOGIES FOR INTEGRATED HELMET SYSTEMS
M. R. WORBOYS (GEC-Marconi Research Centre, Great Baddow, United Kingdom), G. WHITE (Boswells School, Chelmsford, United Kingdom), K. MITCHELL (GEC Avionics, Ltd, Rochester, United Kingdom), and A. MOSLEY (GEC-Marconi, Ltd., Hirst Research Centre, Wembley, United Kingdom) GEC Journal of Research (ISSN 0264-9187) vol. 10, no. 2 1993 p. 111-118. Research supported by Department of Trade and Industry and Ministry of Defence of United Kingdom refs
Copyright

The current status of four types of miniature display technology which are being developed within the GEC's research laboratories for helmet mounted applications is reviewed. These technologies include light emitting diodes, DC thin film electroluminescence, active matrix addressed ferroelectric liquid crystal displays, and ferroelectric electrically-addressed spatial light modulators. Particular attention is given to the systems requirements for integrated helmet display technologies and the factors which govern the choice of a particular display technology. AIAA

A93-35678
INSTRUMENT SYSTEMS OF FLIGHT VEHICLES AND THEIR DESIGN [PRIBORNYE KOMPLEKSY LETATEL'NYKH APPARATOV I IKH PROEKTIROVANIE]
VLADIMIR M. AGEEV and NATALIIA V. PAVLOVA Moscow Izdatel'stvo Mashinostroenie 1990 432 p. In Russian. refs
(ISBN 5-217-00793-1) Copyright

The general principles of the analysis and design of instrument systems for flight vehicles intended for the acquisition and measurement of parameters and for the processing and display of flight data are presented. Some typical instrument clusters are described, and their static and dynamic accuracy characteristics are presented. Attention is also given to signal processing in instrument systems, optimal synthesis of data processing and measurement systems, optimization of the composition of information and instrument systems at the design stage, and examples of the optimization of the composition and structure of instrument systems. AIAA

N93-24764*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVALUATION OF ADVANCED DISPLAYS FOR ENGINE MONITORING AND CONTROL Final Report
L. G. SUMMERS (McDonnell-Douglas Automation Co., Long Beach, CA.) Mar. 1993 71 p
(Contract NAS1-18028; RTOP 505-64-13-12)

(NASA-CR-191418; NAS 1.26:191418; MDC-92K0374) Avail: CASI HC A04/MF A01

The relative effectiveness of two advanced display concepts for monitoring engine performance for commercial transport aircraft was studied. The concepts were the Engine Monitoring and Control System (EMACS) display developed by NASA Langley and a display by exception design. Both of these concepts were based on the philosophy of providing information that is directly related to the pilot's task. Both concepts used a normalized thrust display. In addition, EMACS used column deviation indicators; i.e., the difference between the actual parameter value and the value predicted by an engine model, for engine health monitoring; while the Display by Exception displayed the engine parameters if the automated system detected a difference between the actual and the predicted values. The results showed that the advanced display concepts had shorter detection and response times. There were no differences in any of the results between manual and auto throttles. There were no effects upon perceived workload or performance on the primary flight task. The majority of pilots preferred the advanced displays and thought they were operationally acceptable. Certification of these concepts depends on the validation of the engine model. Recommendations are made to improve both the EMACS and the display by exception display formats. Author (revised)

N93-25783# MacAulay-Brown, Inc., Fairborn, OH.
DEVELOPMENT OF A FLIGHT INSTRUMENT PACKAGE Final Report, 16 Nov. 1987 - 30 Apr. 1991
DAN D. FULGHAM, JOHN L. ORR, and BRIAN MIKITEN Dec. 1992 606 p Prepared in cooperation with Southeastern Center for Electrical Engineering Education (SCEEE)
(Contract F33615-87-C-0534; F33615-87-D-0609)
(AD-A260830; AL/BROOKS-TR-1992-0155) Avail: CASI HC A99/MF A06

Subcontractor (Southwest Research Institute) describes the hardware and software comprising the Flight Instrument Package (FIP), a collection of transducers and electronic components that measure primary flight motion and position parameters and generate digital data representing those parameters. Pitch angle, bank angle, altitude, vertical velocity, airspeed, heading, and angle of attack are the main quantities digitized and relayed to a data port for processing into various displays of aircraft state. The FIP developed as part of this task was used in a Beech Queen Air aircraft to drive the Acoustic Orientation Instrument, which provides the pilot with an auditory display of aircraft bank, airspeed, vertical velocity, and other parameters as necessary. DTIC

N93-25909# MacAulay-Brown, Inc., Dayton, OH.
INFLIGHT EVALUATION OF AN ACOUSTIC ORIENTATION INSTRUMENT Interim Technical Report, 16 Nov. 1987 - 30 Apr. 1991
DAN D. FULGHAM, JOHN L. ORR, and BRIAN MIKITEN Dec. 1992 434 p Prepared in cooperation with MacAulay Brown, Inc., Dayton, OH
(Contract F33615-87-C-0534; F33615-87-D-0609; SWRI PROJ. 12-2301)
(AD-A260752; AL-TR-1992-0160) Avail: CASI HC A19/MF A04

Subcontractor (Southwest Research Institute) provides engineering data and system software description for the Acoustic Orientation Instrument (AOI), which they developed for inflight testing. The overall scheme of operation of the system involves inputting a frame of scaled flight data (airspeed, bank angle, vertical velocity, etc.) from the Flight Instrument Package (FIP) over an RS232 serial link to the AOI, conversion of the flight data to corresponding output voltage waveforms by the AOI, and delivery of those outputs to stereo headphones to generate an auditory display of the flight parameters of interest. This report constitutes an operation and maintenance manual for the AOI, including system programming in the FORTH computer language. DTIC

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A93-33946#
PROBABILISTIC TURBINE BLADE TIP DURABILITY ANALYSIS
R. L. MCKNIGHT, G. S. BECHTEL, and T. S. COOK (GE Aircraft Engines, Cincinnati, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 734-738. refs
(AIAA PAPER 93-1383) Copyright

Probabalistic techniques are used to, investigate cracking in the squealer top region of an air-cooled turbine blade in an Aircraft Gas Turbine Engine (AGTE). This problem had been addressed in a deterministic manner involving 3D transient heat transfer analyses and 3D finite element analyses in conjunction with high-temperature life prediction theories. Technical advances have been made in all areas since this initial analysis. These advanced techniques are used to interrogate a life limiting area in a probabilistic manner and to provide design sensitivity information. Author (revised)

A93-34115#
OPTIMIZATION OF COMPOSITE ENGINE STRUCTURES FOR MECHANICAL AND THERMAL LOADS
SRINIVAS KODIYALAM, V. N. PARTHASARATHY (GE Corporate Research and Development Center, Schenectady, NY), MICHAEL S. HARTLE, and RICHARD L. MCKNIGHT (GE Aircraft Engines, Cincinnati, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 2409-2417. refs
(AIAA PAPER 93-1583) Copyright

A composites optimization capability for aircraft engine components, for structural and thermal design requirements, is currently under development. A heat transfer analysis is coupled to a structural analysis by using the heat transfer results, in terms of the nodal temperatures, in the structural solution. The multidiscipline optimization capability includes provision for providing multiple objective functions and a capability for approximation of the gradients. Several realistic aircraft engine components are optimized for structural, thermal, and/or aeromechanical responses as design objectives and constraints. Author

A93-34159*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN EFFICIENT PROCEDURE FOR CASCADE AEROELASTIC STABILITY DETERMINATION USING NONLINEAR, TIME-MARCHING AERODYNAMIC SOLVERS
APARAJIT J. MAHAJAN, MILIND A. BAKHLE (Toledo Univ.; NASA, Lewis Research Center, Cleveland, OH), and EARL H. DOWELL (Duke Univ., Durham, NC) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2856-2866. refs
(Contract NAG3-724; NAG3-1068; NAG3-1234)
(AIAA PAPER 93-1631) Copyright

A numerical eigenvalue problem formulation and a practical calculation procedure for exact eigenvalues and corresponding

eigenvectors are developed and applied to a nonlinear, two-dimensional, time-marching full potential solver for cascade aeroelastic stability analysis. This procedure is based on the Lanczos recursive method and it directly calculates stability information about a nonlinear steady state. It is compared to conventional approaches in the frequency and time domains developed earlier and is found to be 100-10,000 times more computationally efficient. Eigenvalue constellations and the flutter results for flow through a cascade SR5 propfan airfoil are presented. Author

A93-34160*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL INVESTIGATION OF COUNTER-ROTATING PROPFAN FLUTTER AT CRUISE CONDITIONS
ORAL MEHMED and ANATOLE P. KURKOV (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2867-2875. refs
(AIAA PAPER 93-1632) Copyright

The paper presents wind tunnel experimental flutter results, at transonic relative flows, for a 0.62-m diameter composite propfan model. A blade row that fluttered was tested alone, and with a stable aft counter-rotating blade row. The major objectives of the experiment were to study the effect of the second blade row on the row in flutter, and to investigate the flutter. Results show that the second row had a stabilizing effect. Two distinct flutter modes were found. For both flutter modes: flutter boundary, frequency, nodal diameter, and blade displacement data are given. The blade displacement data, obtained with an optical method, gives an indication of the flutter mode shape at a span near the blade tip. Author

A93-34161*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
UNSTEADY AERODYNAMICS AND FLUTTER OF PROPFANS USING A THREE-DIMENSIONAL FULL-POTENTIAL SOLVER
MILIND A. BAKHLE and T. S. R. REDDY (Toledo Univ., OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2876-2886. refs
(Contract NAG3-1234)
(AIAA PAPER 93-1633) Copyright

A full-potential solver coupled with a linear structural dynamics model is used to calculate the unsteady aerodynamics and aeroelasticity of propfans. The solver allows calculations for arbitrary interblade phase angles. Results are presented for two propfan configurations. Good agreement is seen between the full-potential results and results from linear theory since the flow is subsonic and the thickness of the propfan blades is small. Some difficulty is encountered due to wave reflections from outer computational boundaries; however, this does not affect the results in the range of frequencies of aeroelastic interest. Author

A93-34162*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ON THE STATIC STABILITY OF FORWARD SWEPT PROPFANS
R. SRIVASTAVA (Toledo Univ., OH) and O. MEHMED (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2887-2892. refs
(AIAA PAPER 93-1634)

An hybrid Euler solver coupled with a NASTRAN structural analysis is used to investigate the static stability characteristics of two forward swept propfan blades. The designs, having same geometry but different structural properties - one being statically stable and the other unstable, are analyzed. The stable design takes more iterations to converge than previously designed aft swept blades. The unstable design diverges to an unrealistic shape within five iterations. Author

A93-34165*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
BLASIM - A COMPUTATIONAL TOOL TO ASSESS ICE IMPACT DAMAGE ON ENGINE BLADES
E. S. REDDY, G. H. ABUMERI (Sverdrup Technology, Inc., Brook Park, OH), and C. C. CHAMIS (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2912-2918. refs
(AIAA PAPER 93-1638) Copyright

A portable computer code called BLASIM is developed at NASA LeRC to assess the ice impact damage on aircraft engine blades. In addition to the ice impact analyses, the code is also capable of carrying out static, dynamic, resonance margin and flutter analyses. The blade can be solid, hollow, superhybrid or composite material. An optional preprocessor (input generator) is also developed to generate input to the code through interactive process. The blade geometry can be defined either by a series of airfoils at discrete input stations or by a finite element grid. The code employs a coarse fixed finite element mesh with triangular plate finite elements and has quick turnaround time. The ice piece is modeled as an equivalent spherical object and has the velocity opposite to that of the aircraft with direction parallel to the engine axis. For the local impact damage assessment, the impact force is considered as a distributed load acting over a region around the impact point and the average radial strain of the finite elements along the leading edge is taken as a measure of the local damage. To estimate the damage at the blade root, the impact is considered to be an impulse and a combined stress failure criteria is employed. Parametric studies for local and root ice impact damage, and post-impact dynamics are discussed for solid and composite blades. Author

A93-34375
THRUST VECTORING NOZZLES GIVE PILOTS AN EDGE
MICHAEL PUTTRE Mechanical Engineering (ISSN 0025-6501) vol. 115, no. 3 March 1993 p. 64-67.
Copyright

Experiments on thrust vectoring nozzles carried out by aircraft engine manufactures, NASA, and the armed forces to enhance the maneuverability of fighter jets are described. Particular attention is given to work performed by General Electric (GE) Aircraft Engines and the Pratt and Whitney (P&W) Government Engines and Space Propulsion Division which have developed flight-ready thrust vectoring systems that are being tested in demonstrator aircraft. These systems include a GE axisymmetric vectoring exhaust nozzle for a GE F110 turbofan and a P&W pitch/yaw balance beam nozzle for the P&W F100 line of turbofans. AIAA

A93-34410* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INSTABILITY OF RECTANGULAR JETS
CHRISTOPHER K. W. TAM and ANDREW T. THIES (Florida State Univ., Tallahassee) Journal of Fluid Mechanics (ISSN 0022-1120) vol. 248 March 1993 p. 425-448. refs
(Contract NAG1-421)
Copyright

The instability of rectangular jets is investigated using a vortex-sheet model. It is shown that such jets support four linearly independent families of instability waves. Within each family there are infinitely many modes. A way to classify these modes according to the characteristics of their mode shapes or eigenfunctions is proposed. It is demonstrated that the boundary element method can be used to calculate the dispersion relations and eigenfunctions

of these instability wave modes. The method is robust and efficient. A parametric study of the instability wave characteristics has been carried out. A sample of the numerical results is reported here. It is found that the first and third modes of each instability wave family are corner modes. The pressure fluctuations associated with these instability waves are localized near the corners of the jet. The second mode, however, is a center mode with maximum fluctuations concentrated in the central portion of the jet flow. The center mode has the largest spatial growth rate. It is anticipated that as the instability waves propagate downstream the center mode would emerge as the dominant instability of the jet.

Author

A93-34495
APPROACH OF MODELING CONTINUOUS TURBINE ENGINE OPERATION FROM STARTUP TO SHUTDOWN
M. A. CHAPPELL (Sverdrup Technology, Inc., Arnold AFB, TN) and P. W. MCLAUGHLIN (Simulation and Modelling Workshop, Glastonbury, CT) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 466-471. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991, AIAA Paper 91-2373. Previously cited in issue 17, p. 2865, Accession no. A91-41764 refs
Copyright

A93-34497* National Aeronautics and Space Administration, Washington, DC.
ISSUES ASSOCIATED WITH LONG-DURATION HIGH-ENTHALPY SCRAMJET COMBUSTOR TESTING
M. W. THOMPSON and M. A. FRIEDMAN (Johns Hopkins Univ., Laurel, MD) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 479-485. AIAA, International Aerospace Planes Conference, 3rd, Orlando, FL, Dec. 3-5, 1991, AIAA Paper 91-5104. Previously cited in issue 05, p. 678, Accession no. A92-17862 Research sponsored by National Aerospace Plane Joint Program Office refs
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A93-35685
GAS DYNAMICS OF COOLED TURBINES [GAZODINAMIKA OKHLAZHDAEMYKH TURBIN]
VLADIMIR D. VENEDIKTOV Moscow Izdatel'stvo Mashinostroenie 1990 240 p. In Russian. refs
(ISBN 5-217-00809-1) Copyright

The gasdynamic characteristics of cooled high-temperature turbines and methods for calculating these characteristics are reviewed. Methods are presented for estimating losses associated with the convective or film cooling of turbine blades. The operation characteristics of transonic cooled cascades are examined, and methods for their optimization are presented. Particular attention is given to methods for the experimental study of cooled cascades and turbines. AIAA

N93-24754*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FUEL INJECTOR: AIR SWIRL CHARACTERIZATION AEROTHERMAL MODELING, PHASE 2, VOLUME 1 Final Report
M. NIKJOOY (General Motors Corp., Indianapolis, IN.), H. C. MONGIA (General Motors Corp., Indianapolis, IN.), V. G. MCDONELL (California Univ., Irvine.), and G. S. SAMUELSEN (California Univ., Irvine.) Mar. 1993 407 p
(Contract NAS3-24350; RTOP 505-62-52)
(NASA-CR-189193; E-7593; NAS 1.26:189193) Avail: CASI HC A18/MF A04

A well integrated experimental/analytical investigation was conducted to provide benchmark quality relevant to a prefilming type airblast fuel nozzle and its interaction with the combustor dome air swirler. The experimental investigation included a systematic study of both single-phase flows that involved single and twin co-axial jets with and without swirl. A two-component Phase Doppler Particle Analyzer (PDPA) was used to document the interaction of single and co-axial air jets with glass beads that simulate nonevaporating spray and simultaneously avoid the complexities associated with fuel atomization processes and attendant issues about the specification of relevant boundary conditions. The interaction of jets with methanol spray produced by practical airblast nozzle was also documented in the spatial domain of practical interest. Model assessment activities included the use of three turbulence models (k-epsilon, algebraic second moment (ASM), and differential second moment (DSM)) for the carrier phase, deterministic or stochastic Lagrangian treatment of the dispersed phase, and advanced numerical schemes. Although qualitatively good comparison with data was obtained for most of the cases investigated, the model deficiencies in regard to modeled dissipation rate transport equation, single length scale, pressure-strain correlation, and other critical closure issues need to be resolved before one can achieve the degree of accuracy required to analytically design combustion systems.

Author (revised)

N93-25079*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SCREENING STUDIES OF ADVANCED CONTROL CONCEPTS FOR AIRBREATHING ENGINES
PETER J. OUZTS, CARL F. LORENZO, and WALTER C. MERRILL Mar. 1993 22 p Presented at the 28th Joint Propulsion Conference and Exhibit, Nashville, TN, 6-8 Jul. 1992; sponsored by AIAA, SAE, ASME, and ASEE
(Contract RTOP 505-62-50)
(NASA-TM-106042; E-7620; NAS 1.15:106042) Avail: CASI HC A03/MF A01

The application of advanced control concepts to airbreathing engines may yield significant improvements in aircraft/engine performance and operability. Accordingly, the NASA Lewis Research Center has conducted screening studies of advanced control concepts for airbreathing engines to determine their potential impact on turbine engine performance and operability. The purpose of the studies was to identify concepts which offered high potential yet may incur high research and development risk. A target suite of proposed concepts was formulated by NASA and industry. These concepts were evaluated in a two phase study to quantify each concept's impact on desired engine characteristics. To aid in the evaluation, three target aircraft/engine combinations were considered: a military high performance fighter mission, a high speed civil transport mission, and a civil tiltrotor mission. Each of the advanced control concepts considered in the study were defined and described. The concept's potential impact on engine performance was determined. Relevant figures of merit on which to evaluate the concepts were also determined. Finally, the concepts were ranked with respect to the target aircraft/engine missions. Author

N93-25106*# General Motors Corp., Indianapolis, IN. Allison Gas Turbine Div.
FUEL INJECTOR: AIR SWIRL CHARACTERIZATION AEROTHERMAL MODELING, PHASE 2, VOLUME 2 Final Report
M. NIKJOOY, H. C. MONGIA, V. G. MCDONELL (California Univ., Irvine.), and G. S. SAMUELSON (California Univ., Irvine.) Mar. 1993 294 p
(Contract NAS3-24350; RTOP 505-62-52)
(NASA-CR-189193; E-7593; NAS 1.26:189193) Avail: CASI HC A13/MF A03

A well integrated experimental/analytical investigation was conducted to provide benchmark quality data relevant to prefilming type airblast fuel nozzle and its interaction with combustor dome air swirler. The experimental investigation included a systematic study of both single-phase flows that involved single and twin co-axial jets with and without swirl. A two-component Phase Doppler Particle Analyzer (PDPA) equipment was used to document the interaction of single and co-axial air jets with glass beads that simulate nonevaporating spray and simultaneously avoid the complexities associated with fuel atomization processes and attendant issues about the specification of relevant boundary

conditions. The interaction of jets with methanol spray produced by practical airblast nozzle was also documented in the spatial domain of practical interest. Model assessment activities included the use of three turbulence models (k-epsilon, algebraic second moment (ASM) and differential second moment (DSM)) for the carrier phase, deterministic or stochastic Lagrangian treatment of the dispersed phase, and advanced numerical schemes. Although qualitatively good comparison with data was obtained for most of the cases investigated, the model deficiencies in regard to modeled dissipation rate transport equation, single length scale, pressure-strain correlation, and other critical closure issues need to be resolved before one can achieve the degree of accuracy required to analytically design combustion systems. Author

N93-25129*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL PERFORMANCE OF A VENTRAL NOZZLE WITH PITCH AND YAW VECTORING CAPABILITY FOR SSTOVL AIRCRAFT
BARBARA S. ESKER and JACK G. MCARDLE Apr. 1993 12 p Presented at the Aerospace Atlantic Conference, Dayton, OH, 20-23 Apr. 1993; sponsored by SAE
(Contract RTOP 505-68-32)
(NASA-TM-106054; E-7648; NAS 1.15:106054) Avail: CASI HC A03/MF A01

Aircraft with supersonic, short takeoff, and vertical landing capability were proposed to replace some of the current high-performance aircraft. Several of these configurations use a ventral nozzle in the lower fuselage, aft of the center of gravity, for lift or pitch control. Internal vanes canted at 20 deg were added to a swivel-type ventral nozzle and tested at tailpipe-to-ambient pressure ratios up to 5.0 on the Powered Lift Facility at NASA LeRC. The addition of sets of four and seven vanes decreased the discharge coefficient by at least 6 percent and did not affect the thrust coefficient. Side force produced by the nozzle with vanes was 14 percent or more of the vertical force. In addition, this side force caused only a small loss in vertical force in comparison to the nozzle without vanes. The net thrust force was 8 deg from the vertical for four vanes and 10.5 deg for seven. Author (revised)

N93-25455# Royal Aircraft Establishment, Farnborough (England). Aerospace Div.
MEASUREMENTS AND COMPUTATIONS OF EXTERNAL HEAT TRANSFER AND FILM COOKING IN TURBINES
S. P. HARASGAMA, C. D. BURTON, and K. S. CHANA 24 Feb. 1992 14 p Presented at the 10th International Symposium on Air Breathing Engines, Nottingham, England, 1-6 Sep. 1991 Previously announced in IAA as A91-56238
(RAE-TM-P-1223; BR310269) *Copyright* Avail: CASI HC A03/MF A01

A review of recent work on turbine heat transfer performed at the RAE (Pyestock) is presented. The work covers the effects of secondary flows on turbine nozzle guide vane heat transfer with and without film cooling. It is shown that the heat load to the platforms (end walls) are significantly affected by the secondary flow action. The platform film cooling data has been well correlated with flat plate single row film cooling data to within +11 percent. A three-dimensional Navier-Stokes computational study of the effects of turbine inlet temperature distortion on the thermo-fluid mechanics within a rotating blade passage is given. It is shown that the temperature distortion is modified within the rotor blade and can lead to increased pressure side and over tip heat transfer. Author

N93-25471 Council for National Academic Awards (England).
DESIGN AND PERFORMANCE OF NOZZLE-LESS VOLUTE CASINGS FOR INWARD FLOW RADIAL TURBINES Ph.D. Thesis
HASSAM O. OWARISH 1989 148 p
Avail: Univ. Microfilms Order No. BRDX97192

Inward Flow Radial Turbines are widely used in industry, particularly in turbochargers, small gas turbine engines, and aircraft starters and air conditioning systems. The turbine stage comprises essentially a stator or casing and a rotor. In feeding the flow into the turbine rotor, a well designed casing should achieve the following objectives: (1) acceleration of the working fluid and direct it at a specific angle in to the rotor; (2) production of congruent velocity triangles around the inlet periphery of the rotor; and (3) achieve (1) and (2) with a minimum loss of total pressure. The efficiency of Inward Flow Radial Turbines fitted with vaneless casings is lower than that of similar turbines fitted with the more expensive casings using guide vanes or nozzles. The difference is attributed to the more controlled flow occurring in the vaned casing. It is believed that such a flow can be achieved in the vaneless casing if the state of the art related to design methods is improved. In the past, all design methods have been based on the assumption of one-dimensional free vortex flow. The author's contribution has been in the development of a novel method of flow analysis and design of single-entry vaneless casing. This method is based on two-dimensional flow which takes the shape of the cross-section into account. In this method, the casing is divided into a number of segments which are sub-divided into a number of control volumes. By considering the changes in momenta in the tangential and radial directions across each control volume, together with the equations of energy, state, and continuity of mass, the changes in flow properties are computed. The flow model and the design method were constructed as FORTRAN computer programs that require only the operating conditions, that is mass flow rate, total pressure, and total temperature of entry as input, and make use of numerical methods to solve the equations. The relationships between geometrical dimensions at a fixed set of operating conditions, and the relationships between geometrical dimensions and operating conditions given by this design method have also been studied. Dissert. Abstr.

N93-25480 Maryland Univ., College Park.
OPTIMIZED SCRAMJET ENGINE INTEGRATION ON A WAVERIDER AIRFRAME Ph.D. Thesis
MARY KAE LOCKWOOD ONEILL 1992 205 p
Avail: Univ. Microfilms Order No. DA9304373

One of the keys to the success of air breathing hypersonic vehicles is the effective integration of the air breathing engine with the airframe. The practicality of integrating waveriders with hydrogen fueled scramjet engines is investigated. This is the first study to develop waveriders specifically for the purpose of scramjet integration. A method was developed, and a corresponding computer code was written, to optimize the waverider and scramjet together to take full advantage of the benefits of the waverider while providing the scramjet with the properties required for effective combustion. Two classes of air breathing hypersonic vehicle concepts, one for primarily cruise missions and the other for accelerator type missions, are presented. Cruise configurations are optimized for the product of specific impulse and lift-to-drag ratio while matching lift to weight, corrected for centrifugal force, and thrust to drag at some equivalence ratio. Accelerator configurations are optimized for effective specific impulse while matching lift to weight, corrected for centrifugal force, at an equivalence ratio of one. Waveriders are derived from conical flow-fields, the combustor is modeled with quasi 1-D flow and the inlet and nozzle are modeled with 2-D planar flow. The results of an optimization include the fore body shape, inlet shape, engine location along the length of the vehicle, engine span, vehicle volume, and the approximate values for effective specific impulse, L/D, specific impulse, and center of pressure for the optimized configuration. The results indicate that waveriders are promising configurations for hypersonic vehicles. A 60 m Mach 8 vehicle flying at 50.3 km altitude, optimized for cruise, has an L/D of 4.7, an Isp of 2786 sec, and a 2258 cu m volume. A 60 m Mach 10 cruise vehicle, flying at an altitude of 55.1 km has an L/D of 3.5, an Isp of 2417 sec, and a volume of 2686 cu m. A 60 m Mach 14 accelerator, flying at an altitude of 36.9 km has an Isp(sub eff) of 531 sec and a 3902 cu m volume. A 60 m Mach 10 accelerator, flying at an altitude of 31.8 m has an Isp(sup eff) of 1512 sec and a 4155 cu m volume. Dissert. Abstr.

N93-25668*# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.

THREE-DIMENSIONAL FLOW IN RADIAL TURBOMACHINERY AND ITS IMPACT ON DESIGN Final Report, Sep. 1985 - Oct. 1992

CHOON S. TAN and WILLIAM HAWTHORNE May 1993 15 p (Contract NAG3-772)

(NASA-CR-192957; NAS 1.26:192957) Avail: CASI HC A03/MF A01

In the two papers on the 'Theory of Blade Design for Large Deflections' published in 1984, a new inverse design technique was presented for designing the shape of turbomachinery blades in three-dimensional flow. The technique involves the determination of the blade profile from the specification of a distribution of the product of the radius and the pitched averaged tangential velocity (i.e., r bar-V(sub theta), the mean swirl schedule) within the bladed region. This is in contrast to the conventional inverse design technique for turbomachinery blading in two dimensional flow in which the blade surface pressure or velocity distribution is specified and the blade profile determined as a result; this is feasible in two-dimensional flow because the streamlines along the blade surfaces are known a priori. However, in three-dimensional flow, the stream surface is free to deform within the blade passage so that the streamlines on the blade surfaces are not known a priori; thus it is difficult and not so useful to prescribe the blade surface pressure or velocity distribution and determine the resulting blade profile. It therefore seems logical to prescribe the swirl schedule within the bladed region for designing a turbomachinery blade profile in three-dimensional flow. Furthermore, specifying r bar-V(sub theta) has the following advantages: (1) it is related to the circulation around the blade (i.e., it is an aerodynamic quantity); (2) the work done or extracted is approximately proportional to the overall change in r bar-V(sub theta) across a given blade row (Euler turbine equation); and (3) the rate of change of r bar-V(sub theta) along the mean streamline at the blade is related to the pressure jump across the blade and therefore the blade loading. Since the publications of those two papers, the technique has been applied to the design of a low speed as well as a high speed radial inflow turbine (for turbocharger applications) both of which showed definite improvements in performance over that of wheels of conventional designs, the design study of a high pressure ratio radial inflow turbine with and without splitter blades.

Derived from text

N93-25673*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

GAS TURBINE SYSTEM SIMULATION: AN OBJECT-ORIENTED APPROACH

COLIN K. DRUMMOND, GREGORY J. FOLLEN, and CHARLES W. PUTT Apr. 1993 14 p Presented at the 23rd Annual Pittsburgh Conference on Modeling and Simulation, Pittsburgh, PA, 30 Apr. - 1 May 1992; sponsored by the Univ. of Pittsburgh, IEEE, ISA, and SCS

(Contract RTOP 505-62-51)

(NASA-TM-106044; E-7632; NAS 1.15:106044) Avail: CASI HC A03/MF A01

A prototype gas turbine engine simulation has been developed that offers a generalized framework for the simulation of engines subject to steady-state and transient operating conditions. The prototype is in preliminary form, but it successfully demonstrates the viability of an object-oriented approach for generalized simulation applications. Although object oriented programming languages are-relative to FORTRAN-somewhat austere, it is proposed that gas turbine simulations of an interdisciplinary nature will benefit significantly in terms of code reliability, maintainability, and manageability. This report elucidates specific gas turbine simulation obstacles that an object-oriented framework can overcome and describes the opportunity for interdisciplinary simulation that the approach offers. Author

N93-25702 Cranfield Inst. of Tech., Bedford (England).

NUMERICAL MODELLING OF VISCOUS TURBOMACHINERY FLOWS WITH A PRESSURE CORRECTION METHOD Ph.D. Thesis

A. TOURLIDAKIS 1992 369 p

Avail: *Univ. Microfilms Order No. BRDX97988*

A fully elliptic computational method for the analysis of steady viscous flow in high speed subsonic centrifugal compressor impellers with tip leakage, is presented. A generalized curvilinear, non-orthogonal grid is utilized and the time-averaged Navier-Stokes equations are transformed and expressed in a fully conservative form. The discretization of the governing equations is performed through finite volume integration. The solution procedure employs a non-staggered variable arrangement and a SIMPLE based method for coupling the velocity and pressure fields. The turbulence effects are simulated with the use of the k-epsilon model, modified to account for rotation and streamline curvature, and the near-wall viscous phenomena are modeled through the wall function method. The numerical model is implemented for the flow prediction in a series of two and three dimensional test cases. Incompressible flow predictions in two-dimensional cascades and three-dimensional ducting systems with different geometrical features and inlet conditions are initially performed and the numerical results are compared against available experimental data. The final objective of the present study is achieved through the comparative study of the predictions obtained against the results of Eckardt's experimental investigation of the viscous compressible flow in a high speed radial impeller operating at design condition and in a backswept impeller at design and off-design conditions. In addition, the flow is simulated in the passages of the Rolls Royce GEM impeller which was tested at Cranfield at design and off-design flow rates. A jet/wake pattern was discerned in all the simulated centrifugal compressor cases and a good overall agreement was achieved with the measured wake formation and development; and, encouraging results were obtained on the evolution of the secondary flows. The tip leakage effects influenced the loss distribution, the size and the location of the wake flow pattern at the rotor exit. The effects of the flow mass rate on the detailed flow pattern and on the compressor performance have been well represented. In certain cases, the quality of the present predictions is an improvement over that obtained by other state-of-the-art Navier-Stokes solvers. In conclusion, the developed finite volume flow model has captured a large number of complex flow phenomena encountered in the tested impellers and is expected to provide a useful aerodynamic analysis tool for stationary or rotating, axial or radial turbomachinery components.

Dissert. Abstr.

N93-25751 Council for National Academic Awards (England).

SIMULATION OF AIRCRAFT GAS TURBINE ENGINE Ph.D. Thesis

IBRAHIM H. ISMAIL 1991 260 p

Avail: Univ. Microfilms Order No. BRDX97196

This thesis describes GTES (gas turbine engine simulation) a digital computer program that simulates the design and off-design performance of aircraft gas turbine engines. The program can also perform test analysis for the individual components of these engines. A general description of gas turbine engines and their applications is described in Chapter 1. A review of the previous work (papers and reports) related to this area is covered in Chapter 2. A theoretical background of aerothermodynamics and gas dynamics of gas turbine engines, also the components performance characteristics and performance of the complete engine is discussed in Chapter 3. A general description of the program philosophy and the modules control procedure is explained in Chapter 4. The modelling procedure for each component and for the complete engine is introduced in Chapter 5. A validity of the simulation program results in comparing with available engine test data and the discussion of the simulation result is shown in Chapter 6. The concluding remarks which are derived from this research and the recommendations for further work are included in Chapter 7. The main parts of this program are, data entry, components performance and complete engine run. The main features of this

program are that, it has been written for IBM compatible micro computers and is modular in its approach, at the same time losses in the stationary components have been considered in this work. In author's view this approach is novel and it should make a significant contribution to the simulation work. Dissert. Abstr.

N93-25882# Cranfield Inst. of Tech., Bedford (England).
THE EFFECTS OF REACTION ON AXIAL COMPRESSOR PERFORMANCE Ph.D. Thesis
C. D. FARMAKALIDES 1992 312 p
Avail: Univ. Microfilms Order No. BRDX97979

The present study examined the effects of design point choice of degree of reaction on axial flow compressor performance. The study, which has been partly sponsored by a market leader in industrial compressors, has been born from the need to improve on the compressor's stable operating range preferably at no loss of efficiency. Two kinds of blading, one of 100 percent and one of 80 percent reaction, were designed for mass flow and work coefficients of .6 and .4 respectively. The 80 percent reaction blading was manufactured and together with an existing 50 percent reaction blading has been tested on CIT's three stage axial flow research facility. Tests carried out, using the 50 percent and 80 percent reaction blading, involved measurements of performance over the stable range of operation and included traverse investigation carried out at two flow conditions. Three builds were tested using each blading with stator stagger settings of design, design +10 degrees and design -10 degrees. For the six builds tested, performance measurements were carried out with particular attention given to the operating range and maximum efficiency. Mid pitch radial and mid span circumferential traverse investigation, carried out for flow conditions near optimum and stall, examined the variation of aerodynamic parameters with flow rate and helped to validate methods used for compressor blading design and performance analysis. Analysis of the experimental data was conducted using three performance prediction methods: (1) a simple method based on generalized correlations; (2) a through-flow method STRCUR based on Denton's stream-line curvature calculation technique and applied only to the two builds with design stator stagger settings and for flow conditions near optimum point; and (3) a stream-line curvature method AXCHAR which is based on the solution of a simplified radial equilibrium equation. The experimental findings of this study indicated that high reaction blading can result in some stall margin and stable operating range improvement at no loss of maximum efficiency. Such trends were indicated even when the level of reaction was increased by a stator restaggering process. The analysis carried out indicated that: (1) a simple methods for obtaining the stage characteristic curves are suitable for preliminary analysis; (2) the through-flow code STRCUR can predict the internal flow field provided secondary flow losses are accounted for; and (3) the code AXCHAR is a useful tool for the prediction of stage characteristics and also provides valuable information regarding radial distributions of aerodynamic parameters at flow conditions varying from choke to stall. The analysis identified areas for improvement in the correlations used for stall point and off-design deviation angle prediction. Dissert. Abstr.

N93-25917# Cranfield Inst. of Tech., Bedford (England). Dept. of Turbomachinery and Engineering Mechanics.
RADIAL INFLOW TURBINE STUDY Final Report, 1 Mar. - 30 Jun. 1992
S. HAMID and R. L. ELDER Jul. 1992 120 p
(Contract DAJA45-89-C-0006)
(AD-A260767; CIT/REF-06-769(E); RTD-5824-AN-01) Avail: CASI HC A06/MF A02

Small radial inflow turbines have various applications in industry and are successfully being used as a major component of gas turbines and turbochargers. The performance of the turbine is of great importance for the success of these systems. Although the design of radial inflow turbines has improved in the last few years, the detailed aerodynamic study of these components still needs considerable attention. Better understanding of the flow processes involved in these machines will provide a good basis for the design of improved components and for this purpose a joint research program has been undertaken by Cranfield, the U.S. Army Research Office and Turbomach (San Diego). The main objective of the study was to investigate the flow processes involved in the radial inflow turbine using experimental methods. The work presented in this report describes the various steps undertaken to perform these studies together with results. The project involved two phases, the first measurements downstream of the rotor and the second measurements between the nozzle guide vanes and rotor inlet. The scope of the study was limited to two man years during which considerable success was achieved in obtaining the desired measurement but more time to further reduce this data and to compare with computational results, which was outside the scope of the present study, would have been advantageous. The studies using laser anemometry undertaken downstream of the turbine rotor indicated a swirling flow with a region of counter-rotating flow in the centre. A cobra probe was used to compare with the laser anemometry results. Both measuring techniques show similar trends of flow velocity and flow angle at various running conditions. DTIC

N93-26161*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ROTATING RAKE DESIGN FOR UNIQUE MEASUREMENT OF FAN-GENERATED SPINNING ACOUSTIC MODES
KEVIN E. KONNO and CLIFFORD R. HAUSMANN Apr. 1993 23 p
(Contract RTOP 535-03-01)
(NASA-TM-105946; E-7814; NAS 1.15:105946) Avail: CASI HC A03/MF A01

In light of the current emphasis on noise reduction in subsonic aircraft design, NASA has been actively studying the source of and propagation of noise generated by subsonic fan engines. NASA/LeRC has developed and tested a unique method of accurately measuring these spinning acoustic modes generated by an experimental fan. This mode measuring method is based on the use of a rotating microphone rake. Testing was conducted in the 9 x 15 Low-speed Wind Tunnel. The rotating rake was tested with the Advanced Ducted Propeller (ADP) model. This memorandum discusses the design and performance of the motor/drive system for the fan-synchronized rotating acoustic rake. This novel motor/drive design approach is now being adapted for additional acoustic mode studies in new test rigs as baseline data for the future design of active noise control for subsonic fan engines. Included in this memorandum are the research requirements, motor/drive specifications, test performance results, and a description of the controls and software involved.
Author (revised)

N93-26219# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.
FLOW CONTROL OF LOW HEAT LOAD TURBINE AIRFOILS Final Report, Jul. 1987 - Feb. 1991
A. H. EPSTEIN, G. R. GUENETTE, T. D. STONE, and W. J. STENTOE 28 Feb. 1992 312 p
(Contract F33615-87-C-2729)
(AD-A260941; WL-TR-91-2079) Avail: CASI HC A14/MF A03

The goal of this work was to examine how the heat load to turbines may be reduced by aerodynamic design. The effort consisted of three separate investigations: (1) determination of the effect of small grooves in the flow direction (riblets) on heat transfer, (2) an investigation of the role of inviscid flow aerodynamics on heat load, and (3) examination of the measurement technology required to assess heat transfer and aerodynamic performance in a short duration turbine test facility. For the first effort, a low turbulence, constant wall temperature wind tunnel was constructed with one wall containing riblets. Measurements indicated a maximum of 5 percent reduction in heat transfer and 7 percent in skin friction drag. In the second effort, an integral technique was developed to predict laminar flow heat transfer and drag losses for a two-dimensional airfoil. The integral method was incorporated into the ISES inverse design code and comparisons were made to existing calculational methods

and experimental data. For the third effort, errors associated with heat transfer and aerodynamic performance measurements in short duration (isothermal) test facilities were found to be small but not negligible. It is shown that these errors can be estimated to sufficient accuracy so that data from short duration facilities will have equal or better accuracy than that from conventional turbine rigs. DTIC

N93-26239# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
THE BLADE CURVING EFFECTS IN A TURBINE STATOR CASCADE WITH LOW ASPECT RATIO
WANG ZHONGQI and HAN WANJIN 21 Jan. 1993 16 p Transl. into ENGLISH from Jnl. of Engineering Thermophysics (China), v. 11, no. 3, Aug. 1990 p 255-262
(Contract F33657-84-D-0165)
(AD-A261063; FASTC-ID(RS)T-0312-92) Avail: CASI HC A03/MF A01

In a low speed plane cascade tunnel, the experiments for the cascades equipped with conventional straight blades, linear inclined blades and curvilinear blades were carried out. Through the comparisons of the experimental results, the improving effects of blade curving on the flow fields are discussed. The experimental results show that using curvilinear blades in the rectangular turbine stator cascades with low aspect ratio can reduce the overall flow loss by 30-40%. DTIC

N93-26335# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
ACTIVE STABILIZATION OF AEROMECHANICAL SYSTEMS
Final Technical Report, 1 Nov. 1989 - 31 Oct. 1992
ALAN H. EPSTEIN, EDWARD M. GREITZER, JOHN DUGUNDJI, VINCENT H. GARNIER, and DANIEL L. GYSLING 5 Jan. 1993 161 p
(Contract AF-AFOSR-0059-90)
(AD-A261366; AFOSR-93-0142TR) Avail: CASI HC A08/MF A02

This report details the work on the active control of surge and stall in gas turbine engines. The use of small amplitude waves predicted by theory as stall precursors were tested with experimental data. The nonlinear behavior of such waves was shown to explain much of the data in the literature. This theory was used to design an active stabilization system for rotating stall which was tested on both a single-stage and a three-stage axial compressor, increasing the stable operating range of the single-stage compressor by 25%. The dynamics of the three-stage compressor were shown to match closely with theory. The open-loop forced response characteristics of the compressors were measured and methodology developed in which this data was used to design the compressor control system. The models then developed were used to evaluate alternate control strategies. Engineering of the structural dynamics of the compression system was also shown to be successful in damping rotating stall and surge. DTIC

N93-26339# Naval Air Rework Facility, North Island, CA. Aircraft Environmental Support Office.
PARTICULATE EMISSIONS FROM GAS TURBINE ENGINES
1 Feb. 1992 150 p Revised
(AD-A261374; AESO-2-90-REV) Avail: CASI HC A07/MF A02

The Aircraft Environmental Support Office is one of four specialty offices within the Naval Environmental Protection Support Service which offers technical support to the naval community. The Aircraft Environmental Support Office is primarily responsible for the management and distribution of emissions data for gaseous and particulate air pollutants from aircraft engines. This handbook, Particulate Emissions From Aircraft Engines, is a summary of particulate emissions data collected by the Aircraft Environmental Support Office since 1981. This handbook is intended for environmental personnel at military installations who must provide regulatory agencies with information about particulate matter emitted from their engine test facilities. Most users will find that the sections on visible emissions and particulate emission rates and concentrations contain all the information normally required to make permit applications, emission inventories and related regulatory documents. Also, the section on particle size distributions is appropriate to design applications. Together these sections provide a comprehensive treatment of particulate emissions from aircraft engines. DTIC

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A93-33879#
VIBRATION AND FLUTTER OF STIFF-INPLANE ELASTICALLY TAILORED COMPOSITE ROTOR BLADES
EDWARD C. SMITH (Pennsylvania State Univ., University Park) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 26-37. refs
(AIAA PAPER 93-1302) Copyright

Aeroelastic response, blade and hub loads, and shaft-fixed aeroelastic stability is investigated for a helicopter with elastically tailored stiff-inplane composite rotor blades. A free wake model for nonuniform rotor inflow is integrated with a recently developed finite-element-based aeroelastic analysis for helicopters with tailored composite blades. Pitch-flap and pitch-lag elastic couplings, introduced through the anisotropy of the piles in the blade spar, have a significant effect on the dynamic elastic torsion response. Positive and negative pitch-flap couplings reduce vertical hub shear forces approximately 20 percent in the high vibration transition flight regime, however, negative pitch-flap elastic coupling significantly increases inplane hub shear forces at all flight speeds. The influence of pitch-flap, pitch-lag, and extension-torsion elastic couplings on the rotating frame blade bending moments is small. Ply-induced composite couplings have a powerful effect on blade stability in both hover and forward flight. Positive pitch-flap, positive pitch-lag, and positive extension-torsion couplings each have a stabilizing effect on lag mode damping. Negative pitch-lag coupling has a strong destabilizing effect on blade lag stability, resulting in a mild instability at moderate flight speeds. Author

A93-33880#
AEROMECHANICAL STABILITY OF ROTORCRAFT WITH ADVANCED GEOMETRY BLADES
GUNJIT S. BIR and INDERJIT CHOPRA (Maryland Univ., College Park) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 38-62. refs
(Contract DAAH04-93-G-0001)
(AIAA PAPER 93-1304) Copyright

A new aeroelastic formulation for the advanced geometry blades, involving variable sweep, droop, pretwist and planform, is presented. The blade is modeled as a series of arbitrarily-oriented elastic segments with each segment divided into finite elements. Interelement compatibility relations governing non-Eulerian moderate rotations of the finite elements are also presented. Fuselage dynamic interaction with the advanced geometry blades is included in the formulation. The nonlinear partial differential equations of motion are discretized in space and time using Hamilton's principle. Selective results are presented in hover and forward flight. Results indicate that sweep, and droop in particular, can have a strong influence on both the rotor aeroelastic stability and the rotorcraft aeromechanical stability. Droop can be considerably stabilizing. Sweep increases the blade torsional loads, but is not detrimental to flap and lag vibratory loads. Author

A93-33881#
AEROMECHANICAL STABILITY OF A BEARINGLESS COMPOSITE ROTOR IN FORWARD FLIGHT
ANITA L. TRACY and INDERJIT CHOPRA (Maryland Univ., College Park) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 63-79. refs
(Contract DAAH04-93-G-0001)
(AIAA PAPER 93-1305) Copyright

The aeromechanical stability of a helicopter with an elastically coupled bearingless rotor in forward flight is investigated. A new finite element based structural analysis including the effects of transverse shear and warping restraint is incorporated into the University of Maryland Advanced Rotorcraft Code (UMARC). The effects of transverse shear are implicitly included through static condensation of the shear degrees of motion. The effects of restrained warping are incorporated approximately by modifying the torsional stiffness distributions along the blade. Three soft in-plane bearingless rotor configurations, including bending-torsion structural couplings are analyzed. The analysis covers free flight propulsive trim, blade steady periodic response, and stability of the perturbed rotor-body system. Elastic pitch-lag couplings caused by the ply layup of the flexbeam have a significant effect on the vibratory response, hub loads, and aeroelastic stability of a bearingless rotor. Negative pitch-lag coupling has a stabilizing effect on the lag mode stability in both hover and forward flight.
Author

A93-33929*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FULL-SCALE WIND TUNNEL INVESTIGATION OF A HELICOPTER INDIVIDUAL BLADE CONTROL SYSTEM
STEPHEN A. JACKLIN, JANE A. LEYLAND (NASA, Ames Research Center, Moffett Field, CA), and ACHIM BLAAS (Henschel Flugzeug-Werke GmbH, Kassel, Germany) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 576-586. refs
(AIAA PAPER 93-1361) Copyright

This paper discusses the preparations and plans to test an individual rotor blade pitch control system in the 40- by 80- Foot Wind Tunnel at the NASA Ames Research Center. The test will be performed on a full-scale BO-105 rotor system using a control system made by Henschel Flugzeug-Werke, GmbH, Germany. The Individual Blade Control (IBC) actuators have been designed to replace the pitchlinks of the rotor system. The paper presents a brief historical perspective on the development of the individual blade control system and then describes the present IBC actuators and the wind tunnel test hardware. A discussion of the intended test matrix, expected potential benefits of IBC, and simulation results are included.
Author

A93-33930#
ACTIVE CONTROL OF VIBRATORY AIRLOADS INDUCED BY HELICOPTER ROTOR-FUSELAGE INTERACTIONS
G. L. CROUSE, JR. (Creative System Designs, Laurel, MD) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 587-594. refs
(Contract DAAL03-88-C-0002)
(AIAA PAPER 93-1363) Copyright

Interactional aerodynamic effects are a significant source of rotorcraft vibration, particularly in hover and in low-speed forward flight. Active control is proposed as a means for the reduction of the vibration induced by these interactional effects. A comprehensive rotorcraft analysis, including the effects of rotor-fuselage aerodynamic interactions, has been used to assess the feasibility of active rotor control for this application. It is shown that the vibratory forces on the rotor blades induced by interactional aerodynamic effects can be suppressed using active control methods. However, the pressure fluctuations on the fuselage surface that result from interactional effects are more difficult to suppress and require much stronger control inputs. Control inputs of the magnitude necessary to suppress the pressure fluctuations on the fuselage surface result in a significant load redistribution over the rotor disk and associated changes in rotor performance.
Author

A93-33932*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FURTHER STUDIES USING MATCHED FILTER THEORY AND STOCHASTIC SIMULATION FOR GUST LOADS PREDICTION
ROBERT C. SCOTT (NASA, Langley Research Center, Hampton, VA), ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA), and BOYD PERRY, III (NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 604-616. refs
(AIAA PAPER 93-1365) Copyright

This paper describes two analysis methods - one deterministic, the other stochastic - for computing maximized and time-correlated gust loads for aircraft with nonlinear control systems. The first method is based on matched filter theory; the second is based on stochastic simulation. The paper summarizes the methods, discusses the selection of gust intensity for each method and presents numerical results. A strong similarity between the results from the two methods is seen to exist for both linear and nonlinear configurations.
Author

A93-33974*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ISAC - A TOOL FOR AEROSERVOELASTIC MODELING AND ANALYSIS
WILLIAM M. ADAMS, JR. and SHERWOOD T. HOADLEY (NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1010-1018. refs
(AIAA PAPER 93-1421) Copyright

This paper discusses the capabilities of the Interaction of Structures, Aerodynamics, and Controls (ISAC) system of program modules. The major modeling, analysis, and data management components of ISAC are identified. Equations of motion are displayed for a Laplace-domain representation of the unsteady aerodynamic forces. Options for approximating a frequency-domain representation of unsteady aerodynamic forces with rational functions of the Laplace variable are shown. Linear time invariant state-space equations of motion that result are discussed. Model generation and analyses of stability and dynamic response characteristics are shown for an aeroelastic vehicle which illustrate some of the capabilities of ISAC as a modeling and analysis tool for aeroelastic applications.
Author (revised)

A93-34020#
AN ANALYSIS OF THE POST-INSTABILITY BEHAVIOUR OF A TWO-DIMENSIONAL AIRFOIL WITH A STRUCTURAL NONLINEARITY
S. J. PRICE (McGill Univ., Montreal, Canada), B. H. K. LEE (National Research Council of Canada, Inst. for Aerospace Research, Ottawa), and H. ALIGHANBARI (McGill Univ., Montreal, Canada) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 3 Washington American Institute of Aeronautics and

Astronautics 1993 p. 1452-1460. Research supported by DND, National Research Council of Canada, and NSERC refs
(AIAA PAPER 93-1474) Copyright

A two-dimensional airfoil with a free-play nonlinearity in pitch subject to incompressible flow has been analyzed. The aerodynamic forces on the airfoil were evaluated using Wagner's function and the resulting equations integrated numerically to give time histories of the airfoil motion. Regions of limit cycle oscillation are detected for velocities well below the linear flutter boundary and the existence of these regions is strongly dependent on the initial conditions and properties of the airfoil. Furthermore, for small structural preloads, narrow regions of chaotic motion are obtained, as suggested by power spectral densities, phase-plane plots and Poincare sections of the airfoil time histories. The existence of this chaotic motion is strongly dependent on a number of airfoil parameters, including, mass, frequency ratio, structural damping and preload. Author

A93-34071#
THE USE OF ARTIFICIAL INTELLIGENCE FOR BUFFET ENVIRONMENTS
J. H. JACOBS, C. E. HEDGECOCK, P. F. LICHTENWALNER, L. E. PADO (McDonnell Douglas Aerospace, Saint Louis, MO), and A. E. WASHBURN (Vigyan, Inc., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 1952-1960. refs
(AIAA PAPER 93-1534) Copyright

Cooperative experimental and analytical research between McDonnell Douglas Aerospace (MDA) and NASA Langley Research Center (NASA LaRC) has led to an artificial intelligence procedure for predicting empennage buffeting pressures and elastic response as a function of upstream flow field and geometric conditions. This research program is a continuing MDA effort to develop a unified buffet design methodology. The current effort employs a combined neural network and finite element modeling method to predict flexible tail response based on rigid pressure information. This method is dependent on experimental data to train the neural network algorithms but is robust enough to expand its knowledge base with additional aircraft data. Initial results show an incredible potential to predict accurate RMS and frequency dependent tail pressures as well as flexible response while providing the future capability to incorporate upstream CFD data for advanced design aircraft buffet pressure predictions. Author

A93-34072#
EXACT FLUTTER SOLUTION OF ADVANCED ANISOTROPIC COMPOSITE CANTILEVERED WING STRUCTURES
G. KARPOUZIAN (U.S. Naval Academy, Annapolis, MD) and L. LIBRESCU (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 1961-1966. refs
(AIAA PAPER 93-1535) Copyright

The present dynamic structural model for wings, which encompasses the effects of warp-inhibition, transverse shear, and anisotropy, is used to study the flutter instability of both straight and swept wings, emphasizing the implications of nonclassical effects. Attention is given to the aeroelastic governing system, an alternative form of the governing equations, and the flutter solution methodology; in this last, the eigenvalue problem described by a system of two coupled differential equations with constant coefficients is solved exactly via the Laplace transform technique. AIAA

A93-34075#
X-31A FLIGHT FLUTTER TEST EXCITATION BY CONTROL SURFACES
C. H. HODSON, S. K. DOBBS, M. J. BROSNAN, and J. B. CHEN (Rockwell International Corp., El Segundo, CA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 1998-2008. refs
(AIAA PAPER 93-1538) Copyright

The X-31A flight flutter test program has used the aircraft's primary control surfaces to excite its structural modes over the 0.1-100 Hz frequency range. Attention is presently given to the characteristics and employment of the flutter excitation system, the flight envelope that was cleared, and the test procedures used. Typical time histories of structural responses, and plots of the frequencies and damping vs dynamic pressure and Mach number, are presented. Extrapolation of these plots indicate large flutter margins-of-safety for the X-31A. AIAA

A93-34257* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IMPROVEMENTS IN HOVER DISPLAY DYNAMICS FOR A COMBAT HELICOPTER
MICHELLE M. ESHOW (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and JEFFREY A. SCHROEDER (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38. no. 1 Jan. 1993 p. 17-28. AHS, Annual Forum and Technology Display, 48th, Washington, June 1992 refs
Copyright

This paper describes a piloted simulation conducted on the NASA Ames Vertical Motion Simulator. The objective of the experiment was to investigate the handling qualities benefits attainable using new display law design methods for hover displays. The new display laws provide improved methods to specify the behavior of the display symbol that predicts the vehicle's ground velocity in the horizontal plane; it is the primary symbol that the pilot uses to control aircraft horizontal position. The display law design was applied to the Apache helmet-mounted display format, using the Apache vehicle dynamics to tailor the dynamics of the velocity predictor symbol. The representations of the Apache vehicle used in the display design process and in the simulation were derived from flight data. During the simulation, the new symbol dynamics were seen to improve the pilots' ability to maneuver about hover in poor visual cuing environments. The improvements were manifested in pilot handling qualities ratings and in measured task performance. The paper details the display design techniques, the experiment design and conduct, and the results. Author

A93-34533
GENERALIZED GUIDANCE LAW FOR COLLISION COURSES
YORIAKI BABA, MAKOTO YAMAGUCHI (National Defense Academy, Yokosuka, Japan), and ROBERT M. HOWE (Michigan Univ., Ann Arbor) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 3 May-June 1993 p. 511-516. AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3, p. 1769-1781. Previously cited in issue 21, p. 3601, Accession no. A91-49732 refs
Copyright

A93-34540
ROBUSTNESS EVALUATION OF A FLEXIBLE AIRCRAFT CONTROL SYSTEM
MARK R. ANDERSON (Virginia Polytechnic Inst. and State Univ., Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 3 May-June 1993 p. 564-571. AIAA Guidance, Navigation and Control Conference, Portland, OR, Aug. 20-22, 1990, Technical Papers. Pt. 2, p. 1170-1179. Previously cited in issue 21, p. 3433, Accession no. A90-47698 refs
Copyright

A93-34541
ENHANCEMENT OF ENDURANCE PERFORMANCE BY PERIODIC OPTIMAL CAMBER CONTROL

GOTTFRIED SACHS and RAINER MEHLHORN (Muenchen, Technische Univ., Munich, Germany) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 3 May-June 1993 p. 572-578. AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1, p. 635-641. Previously cited in issue 21, p. 3599, Accession no. A91-49641 refs
Copyright

A93-34542* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SYNTHESIS AND EVALUATION OF AN H2 CONTROL LAW FOR A HOVERING HELICOPTER
MARC D. TAKAHASHI (NASA, Ames Research Center, Moffett Field, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 3 May-June 1993 p. 579-584. AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3, p. 1392-1416. Previously cited in issue 21, p. 3600, Accession no. A91-49710 refs

A93-34545
NEW ANALYTICAL SOLUTIONS FOR PROPORTIONAL NAVIGATION
M. N. RAO (Defence Research and Development Lab., Hyderabad, India) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 3 May-June 1993 p. 591-594. refs
Copyright

The closed-form solution of true proportional navigation (TPN) is presented where the theoretical acceleration gain constant Kr is not zero, together with the derivation of the solution. The generalization developed for the generalized TPN makes it possible to handle any function of line-of-sight angle. AIAA

A93-34550
ZERO-GRAVITY ATMOSPHERIC FLIGHT BY ROBUST NONLINEAR INVERSE DYNAMICS
F. MORA-CAMINO (Ecole Nationale de l'Aviation Civile, Toulouse, France) and A. K. ACHAIBOU (CNRS, Lab. d'Automatique et d'Analyse des Systemes, Toulouse, France) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 3 May-June 1993 p. 604-607. refs
Copyright

The paper presents a design of an autopilot flight control law for the realization of zero-gravity flight maneuvers with a high degree of accuracy, with a sliding controller added as a regulator so that the tracking error resulting from perturbations remains uniformly bounded and arbitrarily small after a finite interval of time. The proposed control law was applied in a simulation study to a single-powered aircraft, in which three classes of uncertainties were considered, including air turbulence, mass turbulence, and thrust uncertainty. In all cases, the use of the sliding controller resulted in great accuracy of the zero-gravity flight. AIAA

A93-35180#
PARAFOIL STEADY TURN RESPONSE TO CONTROL INPUT
GLEN J. BROWN (Vertigo, Inc., Lake Elsinore, CA) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 248-254. refs
(AIAA PAPER 93-1241) Copyright

Parafoil vehicles in maneuvering flight differ significantly from other, 'conventional', aircraft types in that control input produces turn rate, rather than roll rate, and also in that turning is associated with side-slip or 'skid'. The case of a steady turn is analyzed. Expressions for turn response to control input are derived, based on a linearized (constant coefficient) model. Aerodynamic coefficients of a typical parafoil, calculated using a discrete vortex computer program, are tabulated for use in example turn calculations. The program and details of the model geometry are discussed. Examples are calculated, illustrating the effects of scale and wing loading on turn rate and turn radius. Author

A93-35518* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AUTOMATIC GUIDANCE AND CONTROL LAWS FOR HELICOPTER OBSTACLE AVOIDANCE
VICTOR H. L. CHENG (NASA, Ames Research Center, Moffett Field, CA) and T. LAM (Sterling Software, Inc., Palo Alto, CA) *In* 1992 IEEE International Conference on Robotics and Automation, 8th, Nice, France, May 12-14, 1992, Proceedings. Vol. 1 Los Alamitos, CA IEEE Computer Society Press 1992 p. 252-260. refs
Copyright

The authors describe the implementation of a full-function guidance and control system for automatic obstacle avoidance in helicopter nap-of-the-earth (NOE) flight. The guidance function assumes that the helicopter is sufficiently responsive so that the flight path can be readily adjusted at NOE speeds. The controller, basically an autopilot for following the derived flight path, was implemented with parameter values to control a generic helicopter model used in the simulation. Evaluation of the guidance and control system with a 3-dimensional graphical helicopter simulation suggests that the guidance has the potential for providing good and meaningful flight trajectories. Author

N93-24762*# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.
PREDICTION OF FORCES AND MOMENTS FOR HYPERSONIC FLIGHT VEHICLE CONTROL EFFECTORS Final Report
MARK D. MAUGHMER, LYLE N. LONG, NEAL GUILMETTE, and PETER PAGANO 3 May 1993 70 p
(Contract NAG1-849)
(NASA-CR-193033; NAS 1.26:193033) Avail: CASI HC A04/MF A01

This research project includes three distinct phases. For completeness, all three phases of the work are briefly described in this report. The goal was to develop methods of predicting flight control forces and moments for hypersonic vehicles which could be used in a preliminary design environment. The first phase included a preliminary assessment of subsonic/supersonic panel methods and hypersonic local flow inclination methods for such predictions. While these findings clearly indicated the usefulness of such methods for conceptual design activities, deficiencies exist in some areas. Thus, a second phase of research was conducted in which a better understanding was sought for the reasons behind the successes and failures of the methods considered, particularly for the cases at hypersonic Mach numbers. This second phase involved using computational fluid dynamics methods to examine the flow fields in detail. Through these detailed predictions, the deficiencies in the simple surface inclination methods were determined. In the third phase of this work, an improvement to the surface inclination methods was developed. This used a novel method for including viscous effects by modifying the geometry to include the viscous/shock layer. Author (revised)

N93-25199*# California Inst. of Tech., Pasadena.
ROBUST NONLINEAR CONTROL OF VECTORED THRUST AIRCRAFT
JOHN C. DOYLE, RICHARD MURRAY, and JOHN MORRIS 31 May 1993 44 p
(Contract NAG2-792)
(NASA-CR-192727; NAS 1.26:192727) Avail: CASI HC A03/MF A01

An interdisciplinary program in robust control for nonlinear systems with applications to a variety of engineering problems is outlined. Major emphasis will be placed on flight control, with both experimental and analytical studies. This program builds on recent new results in control theory for stability, stabilization, robust stability, robust performance, synthesis, and model reduction in a unified framework using Linear Fractional Transformations (LFT's), Linear Matrix Inequalities (LMI's), and the structured singular value micron. Most of these new advances have been accomplished by the Caltech controls group independently or in collaboration with researchers in other institutions. These recent results offer a new and remarkably unified framework for all aspects of robust control,

but what is particularly important for this program is that they also have important implications for system identification and control of nonlinear systems. This combines well with Caltech's expertise in nonlinear control theory, both in geometric methods and methods for systems with constraints and saturations. Author

N93-25353 California Univ., Berkeley.
CONTROL OF NONLINEAR SYSTEMS UNDER INPUT CONSTRAINTS WITH APPLICATIONS TO FLIGHT CONTROL Ph.D. Thesis
ALBERT W. LEE 1992 137 p
Avail: Univ. Microfilms Order No. DA9304980

In this dissertation, stability and performance enhancement of systems under input constraints are examined. A simultaneous Lyapunov stability problem is solved to examine sufficient conditions for global asymptotic stability of linear plants with input constraints. The sufficient conditions are then extended to systems whose nonlinearities are globally Lipschitz. For performance enhancement, a new design method is introduced to minimize performance degradation resulting from control saturation. Although the theories for input-output linearization and sliding control are well developed, they are not particularly well suited for systems with input constraints. An approximate input-output linearization method is presented to enhance performance of the closed loop systems under input constraints. This method is demonstrated on a longitudinal flight control problem to significantly improve the closed-loop performance. Dissert. Abstr.

N93-25543 Council for National Academic Awards (England).
CONTROL AND OPTIMIZATION OF AIRCRAFT TRAJECTORIES Ph.D. Thesis
YOUNIS SHARIF DAOUD 1991 207 p
Avail: Univ. Microfilms Order No. BRDX97200

The thesis describes a multi-disciplinary program of research which covers three fields of study, namely: control systems engineering; flight dynamics; and numerical optimization. However the main thrust of the research is in the area of control system engineering. A real time computer algorithm has been developed to control and optimize the trajectory of an aircraft during a maneuver along a path in the vertical plane. The equations of motion of a craft represented by a point mass model moving in the vertical plane are known from flight dynamics. These equations are used to define the trajectory and an optimization routine is used to minimize the time of flight along this trajectory. The real time control algorithm controls the movement of the point mass along this trajectory with path and terminal constraints. The optimization utilizes an adjoint control transformation algorithm for solving the two point boundary value problem that describes the optimal control. The initial values of the adjoint multipliers are related non-linearly to the initial values of the controls by which the system is operated. Since the system is practical and initial values are chosen by an iterative optimization scheme, the optimization is solved without the sensitivity problems of the classical method. The optimization yields a reference family of optimal controls; a near optimal guidance law that transfers the aircraft to the vicinity of the reference family is then described. The control commands are fed to the auto-pilot consisting of the reference optimal controls plus correction terms that are linear combinations of the state deviations from reference values, weighted by a set of pre-calculated gains. In contrast to the neighboring optimal guidance scheme, the reference control and state variables as well as the feedback gains are stored as functions of velocity and path angle in the present approach. Numerical results comparing open loop optimal and approximate feedback solutions are presented. These results demonstrate close agreement between the feedback and optimal trajectories for flight in the vertical plane. Dissert. Abstr.

N93-25998*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HELICOPTER LOW-SPEED YAW CONTROL Patent
JOHN C. WILSON, inventor (to NASA), HENRY L. KELLEY, inventor (to NASA), and CYNTHIA A. CROWELL, inventor (to NASA) 11 May 1993 6 p Filed 7 Nov. 1991 Supersedes N92-30025 (30 - 20, p 3406)
(NASA-CASE-LAR-14219-1; US-PATENT-5,209,430; US-PATENT-APPL-SN-788908; US-PATENT-CLASS-244-17.19; US-PATENT-CLASS-244-17.11; US-PATENT-CLASS-244-75R; INT-PATENT-CLASS-B64C-27/00) Avail: US Patent and Trademark Office

A system for improving yaw control at low speeds consists of one strake placed on the upper portion of the fuselage facing the retreating rotor blade and another strake placed on the lower portion of the fuselage facing the advancing rotor blade. These strakes spoil the airflow on the helicopter tail boom during hover, low speed flight, and right or left sidewards flight so that less side thrust is required from the tail rotor.
Official Gazette of the U.S. Patent and Trademark Office

N93-26046*# Maryland Univ., College Park. Dept. of Electrical and Aeronautical Engineering.
TECHNIQUES FOR DESIGNING ROTORCRAFT CONTROL SYSTEMS Annual Report, 1 Apr. 1992 - 31 Mar. 1993
WILLIAM S. LEVINE and JEWEL BARLOW 5 Apr. 1993 48 p (Contract NAG2-794)
(NASA-CR-192960; NAS 1.26:192960) Avail: CASI HC A03/MF A01

This report summarizes the work that was done on the project from 1 Apr. 1992 to 31 Mar. 1993. The main goal of this research is to develop a practical tool for rotorcraft control system design based on interactive optimization tools (CONSOL-OPTCAD) and classical rotorcraft design considerations (ADOCS). This approach enables the designer to combine engineering intuition and experience with parametric optimization. The combination should make it possible to produce a better design faster than would be possible using either pure optimization or pure intuition and experience. We emphasize that the goal of this project is not to develop an algorithm. It is to develop a tool. We want to keep the human designer in the design process to take advantage of his or her experience and creativity. The role of the computer is to perform the calculation necessary to improve and to display the performance of the nominal design. Briefly, during the first year we have connected CONSOL-OPTCAD, an existing software package for optimizing parameters with respect to multiple performance criteria, to a simplified nonlinear simulation of the UH-60 rotorcraft. We have also created mathematical approximations to the Mil-specs for rotorcraft handling qualities and input them into CONSOL-OPTCAD. Finally, we have developed the additional software necessary to use CONSOL-OPTCAD for the design of rotorcraft controllers. Author (revised)

N93-26196# Naval Postgraduate School, Monterey, CA.
DEVELOPMENT AND TESTING OF THE DIGITAL CONTROL SYSTEM FOR THE ARCHYTAS UNMANNED AIR VEHICLE M.S. Thesis
PAUL V. MERZ Dec. 1992 100 p
(AD-A261656) Avail: CASI HC A05/MF A02

The purpose of this study was to develop the digital sampling and control system for an Unmanned Air Vehicle (UAV) designed to takeoff and land vertically and to transition to forward flight. The system is designed to operate from a personal computer through an umbilical cable tethered to the platform for hover tests. The computer controls the sampling and digital conversion of onboard analog sensor signals and sends control-surface commands for pitch, roll, and yaw motions. The thesis effort includes the following four parts: (1) design of a controllable Pulse-Width-Modulated signal to command the servos which operate the various aerodynamic surfaces; (2) sampling and conversion of the signals to the sensors through the programming of an analog-to-digital card installed in the computer; (3) sensor Power-up and parameter verification of onboard devices; and (4) development of various power networks to allow operation of onboard systems prior to engine start with the ability to be self-sustaining once the engine is running. The system was fully tested during ground runs on a thrust/torque test stand. Integration

of the system with the robust controller designed in a concurrent thesis will provide for the stability necessary for the innovative unmanned vehicle. DTIC

N93-26260# Army Research Lab., Aberdeen Proving Ground, MD.
HELICOPTER FORCED RESPONSE VIBRATION ANALYSIS METHOD RTVIB20 Final Report, Jan. 1990 - Jun. 1992
JOSEPH FRIES Feb. 1993 33 p
(Contract DA PROJ. 1L1-62618-AH-80)
(AD-A261809; ARL-TR-75) Avail: CASI HC A03/MF A01

This report describes a helicopter vibration analysis method. In the method the rotor forcing for a single main rotor is calculated by integrating the forces and moments at the rotor center and then applying them to a rigid helicopter airframe. The vibrations (any place in the airframe) are calculated as the response to the applied hub center forces and moments. The method of analysis allows for dissimilar blades in the main rotor to simulate various types of blade damage and the resulting increase in vibrations transmitted into the airframe. The analysis method is generic and can be used to analyze any single main rotor helicopter. An application is made for the UH-60A helicopter, resulting from the loss of outboard sections of one blade of the rotor, and the resulting vibrations in the cockpit are calculated. DTIC

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A93-33704
TWO IMPORTANT IMPROVEMENTS UPON WALL PRESSURE SIGNATURE CORRECTION METHOD OF LOW-SPEED WIND TUNNEL
GUIQING JIANG (China Aerodynamics Research and Development Center, Mianyang) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 4 Dec. 1992 p. 435-443. In Chinese. refs

The authors have recently made two important improvements on the wall pressure signature correction method for tunnel wall interference. In the original method, the wall pressure measurement has to be extended into the asymptotic range downstream of a test model in order to obtain an accurate correction. This requirement limited its application or decreased the correction accuracy. Here is presented a simplified method to remove the measurement range problem above and obtained accurate correction in any case. For pressure tests, an improved correction method is established, resulting in the coordinated correction approach for both pressure and force tests. The results from demonstration experiments on two sets of modes are also presented. It is shown that two important improvements remove the difficulty in practical application of the original method, broadened its applicable range, and increase the correction accuracy in either force or pressure tests. Author (revised)

A93-33732
ON THE PRINCIPLE OF SIDEWALL EFFECTS ON AIRFOIL TESTING
YAOXI SU (Northwestern Polytechnical Univ., Xian, China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 2 June 1992 p. 272-276. In Chinese. refs

In the present paper different interpretations and models of sidewall effects on airfoil testing are discussed, including the trailing vortex model, the leading-edge-horseshoe-vortex model, and the displacement model. The models are examined in the light of experimental observation and the theory of boundary layer-inviscid flow interaction. It is shown that the sidewall effects can be described reasonably either by vortex effect or by displacement effect, as long as it is analyzed correctly. However, the trailing vortices assumption of Preston is found to be erroneous. The leading edge horseshoe vortex model cannot describe the effect correctly because the most of the vorticity in the boundary layer is neglected. The displacement model of Barnwell (1979) gives a better description in general, but the effect of streamwise vorticities is ignored. The models should be and can be improved to take account of all displacement effects and all vorticity effects of three dimensional sidewall boundary layers. Author (revised)

A93-33750
SIMULATION FOR HOT JET BY CRYOGENIC WIND TUNNELS
LIXIN YOU and KEMING CHENG (Nanjing Aeronautical Inst., China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 3 Sept. 1992 p. 402-406. In Chinese. refs

In this paper, concerned similarity parameters for hot jet simulation are discussed, disadvantages of available cold jet and hot jet simulation techniques are studied, and essential merits of hot jet simulation by cryogenic wind tunnels are indicated. Examination shows that cryogenic wind tunnels may perform full-parameter simulation for hot jets by choosing gas mixtures with different components and mole fractions. Author (revised)

A93-34498
HIGH-TEMPERATURE SUPERSONIC COMBUSTION TESTING WITH OPTICAL DIAGNOSTICS
T. E. PARKER, M. G. ALLEN, W. G. REINECKE, H. H. LEGNER, R. R. FOUTTER, and W. T. RAWLINS (Physical Sciences, Inc., Andover, MA) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 486-492. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0761. Previously cited in issue 10, p. 1562, Accession no. A92-27102 refs
(Contract F33615-88-C-2907)

A93-35625
ASYMPTOTIC METHODS FOR THE PREDICTION OF TRANSONIC WIND-TUNNEL WALL INTERFERENCE
N. D. MALMUTH (Rockwell International Science Center, Thousand Oaks, CA), H. JAFROUDI (Southern California Univ., Los Angeles, CA), C. C. WU (California Univ., Los Angeles), R. MCLACHLAN (Colorado Univ., Boulder), and J. D. COLE (Rensselaer Polytechnic Inst., Troy, NY) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 911-918. AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991, AIAA Paper 91-1712. Previously cited in issue 18, p. 3071, Accession no. A91-44334 refs
(Contract F40600-82-C-0005; F40600-84-C-0010)

N93-25080*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA LEWIS 8- BY 6-FOOT SUPERSONIC WIND TUNNEL USER MANUAL
RONALD H. SOEDER Feb. 1993 55 p
(Contract RTOP 505-62-84)
(NASA-TM-105771; E-7196; NAS 1.15:105771) Avail: CASI HC A04/MF A01

The 8- by 6-Foot Supersonic Wind Tunnel (SWT) at Lewis Research Center is available for use by qualified researchers. This manual contains tunnel performance maps which show the range of total temperature, total pressure, static pressure, dynamic pressure, altitude, Reynolds number, and mass flow as a function of test section Mach number. These maps are applicable for both the aerodynamic and propulsion cycle. The 8- by 6-Foot Supersonic Wind Tunnel is an atmospheric facility with a test section Mach number range from 0.36 to 2.0. General support systems (air systems, hydraulic system, hydrogen system, infrared system, laser system, laser sheet system, and schlieren system are also described as are instrumentation and data processing and acquisition systems. Pretest meeting formats are outlined. Tunnel

user responsibility and personal safety requirements are also stated. Author

N93-25178 Tana-Jyra, Ky (Finland).
TRANSMISSION SYSTEM FOR A TRANSFER DEVICE GRIPPING A DOUBLE WHEEL Patent Application
MATTI SINKKONEN, inventor (to Tana-Jyra) 5 Mar. 1992 14 p
(CA-PATENT-APPL-SN-2024585; INT-PATENT-CLASS-B64F-1/10; CTN-93-60683) Copyright Avail: Micromedia Ltd., Technical Information Centre, 165 Hotel de Ville, Place du Portage, Phase 2, Hull, Quebec J8X 3X2, Canada HC

A transmission system is provided for a transfer device gripping a double wheel, intended to move an aircraft or other wheeled device over a base. The transfer device includes at least two friction rollers and motors to drive them, namely one for each ground wheel of the device to be moved. Compression devices are provided to create the compression to press the friction rollers against the ground wheel. The transmission system includes a power device and transmission devices to feed the operating power to the motors. The intention of the invention is to create a transmission for a transfer device that creates a steady push irrespective of a poor location of the pushing point, which is the main undercarriage. The system according to the invention includes devices to feed the operating power separately and independently of each other to each of the motors driving the ground wheel. Author (CISTI)

N93-25574*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
USE OF HIGH PERFORMANCE NETWORKS AND SUPERCOMPUTERS FOR REAL-TIME FLIGHT SIMULATION
JEFF I. CLEVELAND, II *In* NASA, Washington, Technology 2002: The Third National Technology Transfer Conference and Exposition, Volume 1 p 129-138 Feb. 1993
Avail: CASI HC A02/MF A04

In order to meet the stringent time-critical requirements for real-time man-in-the-loop flight simulation, computer processing operations must be consistent in processing time and be completed in as short a time as possible. These operations include simulation mathematical model computation and data input/output to the simulators. In 1986, in response to increased demands for flight simulation performance, NASA's Langley Research Center (LaRC), working with the contractor, developed extensions to the Computer Automated Measurement and Control (CAMAC) technology which resulted in a factor of ten increase in the effective bandwidth and reduced latency of modules necessary for simulator communication. This technology extension is being used by more than 80 leading technological developers in the United States, Canada, and Europe. Included among the commercial applications are nuclear process control, power grid analysis, process monitoring, real-time simulation, and radar data acquisition. Personnel at LaRC are completing the development of the use of supercomputers for mathematical model computation to support real-time flight simulation. This includes the development of a real-time operating system and development of specialized software and hardware for the simulator network. This paper describes the data acquisition technology and the development of supercomputing for flight simulation. Author

N93-25656# Texas Univ., Austin.
EXPEDIENT REPAIR OF STRUCTURAL FACILITIES Final Report, 1 Jul. 1987 - 1 Jun. 1989
J. O. JIRSA, A. TERAN, and P. T. NASH May 1992 148 p
(Contract AF PROJ. 2104)
(AD-A260727; AFESC/ESL-TR-88-79) Avail: CASI HC A07/MF A02

Damaged airbase facilities critical to restoring aircraft operations must be repaired quickly after an attack to provide the needed support. Repair technologies have been developed in earthquake damage research which have potential application to bomb damage repair. This report describes the repair techniques developed for earthquake damage and their potential application to bomb damage repair. Although the damage mechanisms from earthquake loads are quite different from damage mechanisms of blast loads, the damage resulting to structural elements can be quite similar. Typical damages and failure mechanisms are categorized and compared for earthquake and conventional weapon loadings. Typical structures are selected based upon design guidelines. Damages expected to the typical structures from conventional weapon attack are described. Functional damages are defined and methods for accomplishing facility repairs are then recommended depending upon the facility function and the degree of damage. Materials, equipment, and procedures developed for repairing earthquake damage are described along with their potential use in repairing bomb damages. DTIC

N93-25996* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NOZZLE DIFFUSER FOR USE WITH AN OPEN TEST SECTION OF A WIND TUNNEL Patent
P. STEPHEN BARNA, inventor (to NASA) 18 May 1993 9 p
Filed 8 Aug. 1991 Supersedes N91-32149 (29 - 24, p 3963)
(NASA-CASE-LAR-14424-1-SB; US-PATENT-5,211,057; US-PATENT-APPL-SN-743468; US-PATENT-CLASS-73-147; INT-PATENT-CLASS-G01M-9/00) Avail: US Patent and Trademark Office

The nozzle diffuser has an inlet in fluid communication with the narrowed inlet of an open test chamber in a conventional wind tunnel. The nozzle diffuser has a passageway extending from its inlet to an outlet in communication with the open test section. The passageway has an internal cross sectional area which increases from its inlet to its outlet and which may be defined by top and bottom isosceles trapezoid walls of a particular flare angle and by isosceles trapezoid side walls of a different flare angle. In addition, a collector having a decreasing internal cross sectional area from inlet to outlet may be provided at the opposite end of the test chamber such that its outlet is in communication with a diffuser located at this outlet.
Official Gazette of the U.S. Patent and Trademark Office

N93-26006* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VISUALIZATION OF A MACH 2 REACTING FLOW USING PLANAR LASER-INDUCED FLUORESCENCE (PLIF)
R. JEFFREY BALLA *In* JHU, 29th JANNAF Combustion Subcommittee Meeting, Volume 2 p 1-7 Oct. 1992
Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

Planar laser-induced fluorescence (PLIF) has been used to study the mixing and combustion processes in a coaxial hydrogen/vitiated air turbulent reacting flow. Objectives of this study include providing qualitative information about: (1) the location of flow constituents; (2) the size, location, and orientation of instantaneous and average flow structures; and (3) the unsteadiness of the flow field. The flow facility consists of an inner fuel jet (I.D.= 2.36 mm) which injects hydrogen (Mach = 1 at 550K) and an outer jet (I.D. = 17.8 mm) which injects vitiated air (Mach = 2 at 1250K). This coaxial arrangement generates a turbulent diffusion flame. The flow field is visualized using a tunable excimer laser operating with XeCl and having a pulse length of 20 nanoseconds. The laser beam is formed into a sheet approximately 12.7 cm high and 0.3 mm thick. Laser-induced fluorescence (LIF) is generated by tuning the laser to 32,441.85 cm(exp -1) which excites the Q1(3) transition in the (0-0) band of the A 2Sigma(+) - X 2Pai system of OH. The fluorescence from all emission lines of the (0-0) band is imaged on an intensified CCD array detector, digitized, and stored for later analysis. Instantaneous images provide insight into the flow field which the average data cannot. Preliminary results indicate the presence of both large and small scale flow features in the instantaneous laser snapshots generated from the OH PLIF. In approximately 5-10 percent of the instantaneous images, the PLIF signal is minimal over a significant fraction of the flow field. Finally, it is observed

that OH is present in the vitiated air and is transported over a significant fraction of the flow field. Author

N93-26498# Argonne National Lab., IL. Advanced Photon Source Div.
POSTER SESSION: FIFTH USERS MEETING FOR THE ADVANCED PHOTON SOURCE
Nov. 1992 225 p Meeting held in Argonne, IL, 14-15 Oct. 1992
(Contract W-31-109-ENG-38)
(DE93-006019; ANL/APS/TM-11; CONF-9210290-SUMM) Avail: CASI HC A10/MF A03

The Advanced Photon Source (APS), which is currently under construction as a national user facility at Argonne National Laboratory is a third-generation synchrotron x-ray source, one of only three in the world. It is expected to produce x-rays that are 10,000 times brighter than any currently produced elsewhere for use in research in a wide range of scientific areas. Users from industry, national laboratories, universities, and business will be able to come to the APS to conduct research either as members of Collaborative Access Teams (CAT's) or as Independent Investigators. Principal users will be members of CAT's, which will be building and operating all of the beamlines present in the first phase of APS beamline development. The first set of CAT's has been selected through a competitive proposal process involving peer scientific review, thorough technical evaluation, and significant management oversight by the APS. This document is a compilation of posters presented at the Fifth Users Meeting for the Advanced Photon Source, held at Argonne National Laboratory on October 14-15, 1992. All CAT's whose scientific cases were approved by the APS Proposal Evaluation Board are included. In addition, this document contains a poster from the Center for Synchrotron Radiation and Research and Instrumentation at the Illinois Institute of Technology. DOE

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A93-33889*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN OVERVIEW OF AEROELASTICITY STUDIES FOR THE NATIONAL AERO-SPACE PLANE
RODNEY H. RICKETTS, THOMAS E. NOLL, WOODROW WHITLOW, JR. (NASA, Langley Research Center, Hampton, VA), and LAWRENCE J. HUTTSELL (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 152-162. refs
(AIAA PAPER 93-1313) Copyright

The National Aero-Space Plane (NASP), or X-30, is a single-stage-to-orbit vehicle that is designed to takeoff and land on conventional runways. Research in aeroelasticity was conducted by the NASA and the Wright Laboratory to support the design of a flight vehicle by the national contractor team. This research includes the development of new computational codes for predicting unsteady aerodynamic pressures. In addition, studies were conducted to determine the aerodynamic heating effects on vehicle aeroelasticity and to determine the effects of fuselage flexibility on the stability of the control systems. It also includes the testing of scale models to better understand the aeroelastic behavior of the X-30 and to obtain data for code validation and correlation. This paper presents an overview of the aeroelastic research which has been conducted to support the airframe design. Author

A93-33890*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AEROELASTIC CHARACTER OF A NATIONAL AEROSPACE PLANE DEMONSTRATOR CONCEPT
CHARLES V. SPAIN, THOMAS A. ZEILER, MICHAEL D. GIBBONS, DAVID L. SOISTMANN (Lockheed Engineering and Sciences Co., Hampton, VA), PETER POZEFSKY (McDonnell Aircraft Co., Saint Louis, MO), RAFAEL O. DEJESUS (Purdue Univ., West Lafayette, IN), and CYPRIAN P. BRANNON (Georgia Inst. of Technology, Atlanta) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 163-170. Research supported by NASA refs
(AIAA PAPER 93-1314)

The paper provides an analytical assessment of the flutter character of an unclassified National Aerospace Plane configuration known as the demonstrator. Linear subsonic, supersonic, and hypersonic analysis indicate that the vehicle is prone to body-freedom flutter resulting from the decrease in vibration frequency of the all-moveable wing at high flight dynamic pressures. As the wing-pivot frequency decreases, it couples with the vehicle short-period mode resulting in dynamic instability. A similar instability sometimes occurs when the pivot mode couples with the fuselage-bending mode. Also assessed, for supersonic flight conditions, are configuration variations that include relocation of the wing further aft on the lifting-body fuselage, and the addition of body flaps to the rear of the vehicle. These changes are destabilizing because they result in severe wing-pivot/fuselage-bending instabilities at dynamic pressures lower than the instabilities indicated for the original demonstrator. Finally, a two-point wing support and actuation system concept is proposed for the National Aerospace Plane, which if developed may (according to cursory analysis) enhance overall stability. Author

A93-33891*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EXPERIMENTAL AND ANALYTICAL STUDY OF A LIFTING-BODY WIND-TUNNEL MODEL EXHIBITING BODY-FREEDOM FLUTTER
DAVID L. SOISTMANN and CHARLES V. SPAIN (Lockheed Engineering and Sciences Co., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 171-181. Research supported by NASA refs
(AIAA PAPER 93-1316)

Flutter analysis of the proposed National Aerospace Plane indicates that in the subsonic to transonic flight regime, the vehicle may be susceptible to an instability known as body-freedom flutter. Body-freedom flutter is a dynamic instability involving a vehicle rigid-body mode coupling with one or more of the vehicle's elastic modes. In the case of the NASP, the body-freedom flutter predicted by analysis involves the short-period mode of the vehicle coupling with the pivot mode of the all-movable wings. A wind-tunnel test was designed to investigate this phenomenon. Parameter studies included variations in wing-actuator stiffness, wing-pivot shaft location along the root chord, and thickness of the fuselage. The wind-tunnel test was conducted in the NASA Langley Transonic Dynamics Tunnel. Flutter boundaries were measured in the wind tunnel for three configurations and a model divergence point was measured on a fourth configuration. At the last flutter point obtained during the test, body-freedom flutter proved to be rather violent.

The analysis used in this study incorporated thin-wing theory aerodynamics and did a fairly good job of predicting the flutter boundaries. Author

A93-33933*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AEROTHERMOELASTIC ANALYSIS OF A NASP DEMONSTRATOR MODEL
JENNIFER HEEG (NASA, Langley Research Center, Hampton, VA), THOMAS A. ZEILER, ANTHONY S. POTOTZKY, CHARLES V. SPAIN (Lockheed Engineering and Sciences Co., Hampton, VA), and WALTER C. ENGELUND (NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 617-627. refs
(AIAA PAPER 93-1366) Copyright

The proposed National AeroSpace Plane (NASP) is designed to travel at speeds up to Mach 25. Because aerodynamic heating during high-speed flight through the atmosphere could destiffen a structure, significant couplings between the elastic and rigid body modes could result in lower flutter speeds and more pronounced aeroelastic response characteristics. These speeds will also generate thermal loads on the structure. The purpose of this research is develop methodologies applicable to the NASP and to apply them to a representative model to determine its aerothermoelastic characteristics when subjected to these thermal loads. This paper describes an aerothermoelastic analysis of the generic hypersonic vehicle configuration. The steps involved in this analysis were: (1) generating vehicle surface temperatures at the appropriate flight conditions; (2) applying these temperatures to the vehicle's structure to predict changes in the stiffness resulting from material property degradation; (3) predicting the vibration characteristics of the heated structure at the various temperature conditions; (4) performing aerodynamic analyses; and (5) conducting flutter analysis of the heated vehicle. Results of these analyses and conclusions representative of a NASP vehicle are provided in this paper. Author

A93-33934*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPACT OF AEROELASTICITY ON PROPULSION AND LONGITUDINAL FLIGHT DYNAMICS OF AN AIR-BREATHING HYPERSONIC VEHICLE
DAVID L. RANEY, JOHN D. MCMINN (NASA, Langley Research Center, Hampton, VA), ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA), and CHRISTINE L. WOOLEY (Cincinnati Univ., OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 628-637. refs
(AIAA PAPER 93-1367) Copyright

Many air-breathing hypersonic aerospacecraft design concepts incorporate an elongated fuselage forebody acting as the aerodynamic compression surface for a hypersonic combustion module, or scram jet. This highly integrated design approach creates the potential for an unprecedented form of aero-propulsive-elastic interaction in which deflections of the vehicle fuselage give rise to propulsion transients, producing force and moment variations that may adversely impact the rigid body flight dynamics and/or further excite the fuselage bending modes. To investigate the potential for such interactions, a math model was developed which included the longitudinal flight dynamics, propulsion system, and first seven elastic modes of a hypersonic air-breathing vehicle. Perturbation time histories from a simulation incorporating this math model are presented that quantify the propulsive force and moment variations resulting from aeroelastic vehicle deflections. Root locus plots are presented to illustrate the effect of feeding the propulsive perturbations back into the aeroelastic model. A concluding section summarizes the implications of the observed effects for highly integrated hypersonic air-breathing vehicle concepts. Author

A93-34265
SPACEPLANES - BACK TO THE FUTURE
DOUG MILLARD (Science Museum, London, United Kingdom) Spaceflight (ISSN 0038-6340) vol. 35, no. 3 March 1993 p. 74-77. refs
Copyright

The history of spaceplanes from the earliest concepts up to the present day is reviewed. Particular attention is given to the UK's HOTOL, Germany's SAeNGER, and USA's NASP programs, which are based on different concepts to launch a winged reusable orbiter into space. Spaceplane engineers argue that, despite high capital expenditure on research and development, these reusable systems would eventually cut the cost of putting a payload into orbit considerably. AIAA

A93-34266
MAKS - EASTERN PROMISE?
MARK HEMPSELL and BOB PARKINSON (British Interplanetary Society, London, United Kingdom) Spaceflight (ISSN 0038-6340) vol. 35, no. 3 March 1993 p. 79-83.
Copyright

The history and technical details of a MAKS project of multipurpose aerospace system developed in Moscow by NPO Molnija is described. The current MAKS configuration has a 20 m long winged orbiter and a single drop tank containing all the ascent propellant. Three versions of MAKS has been designed including the manned version for crew transfer missions, the unmanned version for delivery of cargo, and a totally expendable version, called MAKS-T. The MAKS orbiter will use an RD-701 engine developed by NPO Energomash. The RD-701 is a twin chambered engine capable of operating as an oxygen-hydrogene-kerosine engine for high trust, or a pure oxygen-hydrogene engine for high performance measured by specific impulse. The MAKS project is considered to be promising route to low cost flexible transportation into LEO. AIAA

A93-35171*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
DESIGN OF A RECOVERY SYSTEM FOR A REENTRY VEHICLE
WULF VON ECKROTH (Thiokol Corp.; NASA, Kennedy Space Center, Cocoa Beach, FL), WILLIAM L. GARRARD (Minnesota Univ., Minneapolis), and NORMAN MILLER (Paradyne Associates, Minneapolis, MN) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 178-187. Research supported by U.S. Army and McDonnell Douglas Space Systems Co refs
(AIAA PAPER 93-1224) Copyright

Engineers are often required to design decelerator systems which are deployed in cross-wind orientations. If the system is not designed to minimize 'line sail', damage to the parachutes could result. A Reentry Vehicle Analysis Code (RVAC) and an accompanying graphics animation software program (DISPLAY) are presented in this paper. These computer codes allow the user to quickly apply the Purvis line sail modeling technique to any vehicle and then observe the relative motion of the vehicle, nose cap, suspension lines, pilot and drogue bags and canopies on a computer screen. Data files are created which allow plots of velocities, spacial positions, and dynamic pressures versus time to be generated. The code is an important tool for the design engineer because it integrates two degrees of freedom (DOF) line sail equations with a three DOF model of the reentry body and jettisoned nose cap to provide an animated output. Author

N93-24899# Electro Magnetic Applications, Inc., Lakewood, CO.
DEVELOPMENT OF MODELS FOR PREDICTING THE TRIGGERING OF LIGHTNING BY LAUNCH VEHICLES
RODNEY A. PERALA, TERENCE H. RUDOLPH, and CALVIN C. EASTERBROOK *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 11 p Nov. 1992
Avail: CASI HC A03/MF A03

As evidenced by incidents on Apollo 12 and AC-67 launches, the threat to launch vehicles from triggered lightning is real. Even in the absence of naturally occurring lightning, it is possible for a launch vehicle with attached plume to amplify atmospheric electric fields to an extent such that an electrical discharge can happen. Therefore, launch rules which are based on the presence of natural lightning in the vicinity may be inadequate to ensure that a triggered strike cannot occur. In order to develop adequate launch guidelines with respect to triggered lightning, it is necessary to first thoroughly understand the physical mechanisms leading to the triggered strike. To this end, we have begun to develop a triggered lightning model which will allow one to predict in advance the conditions under which a lightning strike will occur to a launch vehicle during ascent. The purpose of this paper is to describe the project and the technical issues, and to present some preliminary results. Author

N93-25272 Illinois Univ. at Urbana-Champaign, Savoy.
OPTIMAL FINITE-THRUST TIME-BOUNDED DIRECT-ASCENT INTERCEPTION Ph.D. Thesis
JAMES REAGLE DOWNEY 1992 178 p
Avail: Univ. Microfilms Order No. DA9305510

Minimum-time and maximum final mass solutions are obtained for the problem of direct-ascent interception, from an arbitrary launch point on the surface of the Earth, of a target in a circular orbit. The intercepting rocket is assumed to have finite, bounded thrust and is subject to aerodynamic forces including lift and drag. The effect of Earth rotation is included and an initial waiting period or coast arc prior to launch is allowed. The problem is formulated as an optimal control problem with the objective of determining the thrust magnitude, aerodynamic pointing angle (pitch and yaw), and thrust vectoring angle histories to accomplish the interception. The continuous optimal control problem is converted to a discrete nonlinear programming problem and direct collocation is used to find numerical solutions. Solutions are found for both time-open and time-fixed problems. Optimal solutions include both postgrade and retrograde intercept trajectories. Solutions are obtained for a range of target orbit radii, inclinations, launch points, and initial target locations relative to the launch points. Problems which may include a singular arc as part of the optimal trajectory are also considered, and a method is demonstrated which allows such problems to be solved using direct collocation. Dissert. Abstr.

N93-26012 Alabama Univ., Huntsville. Dept. of Mechanical Engineering.
TURBULENCE INTERACTING WITH CHEMICAL KINETICS IN AIRBREATHING COMBUSTION OF DUCTED ROCKETS
T. J. CHUNG and W. S. YOON *In* JHU, 29th JANNAF Combustion Subcommittee Meeting, Volume 2 p 77-90 Oct. 1992
Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

Physical interactions between turbulence and shock waves are very complex phenomena. If these interactions take place in chemically reacting flows the degree of complexity increases dramatically. Examples of applications may be cited in the area of supersonic combustion, in which the controlled generation of turbulence and/or large scale vortices in the mixing and flame holding zones is crucial for efficient combustion. Equally important, shock waves interacting with turbulence and chemical reactions affect the combustor flowfield resulting in enhanced relaxation and chemical reaction rates. Chemical reactions in turn contribute to dispersion of shock waves and reduction of turbulent kinetic energies. Computational schemes to address these physical phenomena must be capable of resolving various length and time scales. These scales are widely disparate and the most optimum approach is found in explicit/ implicit adjustable schemes for the Navier-Stokes solver. This is accomplished by means of the generalized Taylor-Galerkin (GTG) finite element formulations. Adaptive meshes are used in order to assure efficiency and accuracy of solutions. Various benchmark problems are presented for illustration of the theory and applications. Geometries of ducted rockets, supersonic diffusers, flame holders, and hypersonic inlets are included. Merits of proposed schemes are demonstrated through these example problems. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A93-33963#
LOW VELOCITY IMPACT IN A GRAPHITE/PEEK
E. DEMUTS (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 901-908. refs
(AIAA PAPER 93-1403)

The objective of experimentally investigating the response of AS4/APC-2 graphite polyetheretherketone (Gr/PEEK), when subjected to low velocity nonpenetrating impact, has been achieved by determining at room temperature dry conditions the post impact compressive strength (PICS) for laminates having five different thicknesses (9 to 96 plies) for each of two layups (40/50/10 and 60/30/10). The PICS as well as the damaged areas and indentation depths of the Gr/PEEK have been compared with those of IM7/5260 graphite bismaleimide (Gr/BMI). The impact severity was governed by cuffent USAF structural integrity requirements to produce the initial damage assumption. For laminates thinner than approximately 70 plies, the PICs of Gr/PEEK was found to be superior to that of Gr/BMI. For laminates thicker than 70 plies, however, the roles were reversed. Author (revised)

A93-33989*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
QUANTIFICATION OF UNCERTAINTIES IN COMPOSITES
D. G. LIAW, S. N. SINGHAL (Sverdrup Technology, Inc., Brook Park, OH), P. L. N. MURTHY, and CHRISTOS C. CHAMIS (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1163-1173. refs
(AIAA PAPER 93-1440) Copyright

An integrated methodology is developed for computationally simulating the probabilistic composite material properties at all composite scales. The simulation requires minimum input consisting of the description of uncertainties at the lowest scale (fiber and matrix constituents) of the composite and in the fabrication process variables. The methodology allows the determination of the sensitivity of the composite material behavior to all the relevant primitive variables. This information is crucial for reducing the undesirable scatter in composite behavior at its macro scale by reducing the uncertainties in the most influential primitive variables at the micro scale. The methodology is computationally efficient. The computational time required by the methodology described herein is an order of magnitude less than that for Monte Carlo Simulation. The methodology has been implemented into the computer code PICAN (Probabilistic Integrated Composite ANalyzer). The accuracy and efficiency of the methodology/code

are demonstrated by simulating the uncertainties in the heat-transfer, thermal, and mechanical properties of a typical laminate and comparing the results with the Monte Carlo simulation method and experimental data. The important observation is that the computational simulation for probabilistic composite mechanics has sufficient flexibility to capture the observed scatter in composite properties. Author

A93-34510* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
GAS PHASE HYDROGEN PERMEATION IN A NI-FE-CO SUPERALLOY
MICKEY R. SHANABARGER (California Univ., Santa Barbara) Scripta Metallurgica et Materialia (ISSN 0956-716X) vol. 28, no. 9 May 1, 1993 p. 1143-1148. refs
(Contract NCC2-63)
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Hydrogen permeation measurements have been conducted for the Incoloy 909 Ni-Fe-Co superalloy via the 'membrane' technique, in which the gaseous hydrogen at the entrance of a thin membrane is transposed through the bulk to the exit side of the membrane, at 400-810 C; the pressure range explored was 2.7 x 10 exp 3 to 1.3 x 10 exp 5 N/sq m. The lattice hydrogen solubility of Incoloy 909 is found to be only weakly temperature-dependent. These results are compared with those obtained for Incoloy 903. AIAA

A93-34561
FERROGRAPHIC ANALYSIS OF POLYPHENYL ETHER FLUIDS
HOOVER A. SMITH and COSTANDY S. SABA (Dayton Univ., OH) Wear (ISSN 0043-1648) vol. 161, no. 1-2 April 1, 1993 p. 87-92. refs
(Contract F33615-88-C-2817)
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The paper investigates ferrography for isolating and examining wear debris in polyphenyl ether (PPE) fluids. Samples of military specification MIL-L-87100 type lubricant obtained from operational turbine engines and PPE fluids containing wear debris obtained from sliding four-ball and rolling four-ball wear testing and from corrosion and oxidation (C&O) testing were used. The effects of various sliding wear test parameters as temperature and load on the production of wear debris and subsequent ferrographic analysis are determined. Ferrographic results from sliding wear, rolling wear, filtration, and C&O testing are compared. The normally used dilution of 3 parts oil to 1 part fixer in preparing analytical ferrographs of PPE fluid and PPE type lubricants is not satisfactory. The analytical ferrograph can be of great utility in determining the morphology of wear debris and polymeric material generated in MIL-L-87100 type lubricants. AIAA

A93-35299
PROTECTIVE PROPERTIES OF AVIATION OILS [ZASHCHITNYE SVOISTVA AVIATSIONNYKH MASEL]
A. I. ECHIN, V. A. MITIAGIN, A. N. ZAITSEVA, and V. G. KUZNETSOV (Gosudarstvennyi NII Khimicheskoi Promyshlennosti, Russia) Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169) no. 9 1992 p. 14, 15. In Russian. refs
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The possibility of employing used aviation oils for the protection of aviation engines during storage is investigated. Experimental data are presented on the properties of several mineral and synthetic aviation motor oils, with and without protective additives, following a service period of 6000 km. It is shown that the protective properties of oils without additives improve after service and those of oils with additives remain sufficiently high. The results confirm the possibility of using oxidized motor oils for the temporary protection of aviation engines during storage, transportation, and repairs. AIAA

A93-35618
APPLICATIONS OF SHOCK-INDUCED MIXING TO SUPERSONIC COMBUSTION
JOSEPH YANG, TOSHI KUBOTA, and EDWARD E. ZUKOSKI (California Inst. of Technology, Pasadena) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 854-862. Research supported by NSF and U.S. Navy refs
(Contract F49620-86-C-0113; AF-AFOSR-90-0188)
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Families of two-dimensional, unsteady shock-induced vortical flows are simulated numerically. The flows consist of one or more regions of light gas, surrounded by heavy gas, being overtaken by a normal shock wave. The interaction of the density gradient at each light/heavy interface with the pressure gradient from the shock wave generates vorticity. This causes the light gas regions to roll up into one or more counter-rotating vortex pairs, which stir and mix the light and heavy gases. The mixing is characterized by an asymptotic stretching rate. The effects of shock strength, light/heavy gas density ratio, and geometry on the mixing are investigated. These two-dimensional, unsteady flows are analogous to three-dimensional, steady flows that may be used in SCRAMJET combustors demanding rapid and efficient mixing of fuel and oxidizer. For such applications: (1) the fuel injectors should be elongated in the direction of the shock; (2) multiple smaller injectors are preferable to a single larger injector; (3) injectors should be arranged in groups of closely spaced pairs, rather than uniformly; and (4) multiple shock waves should be utilized, if possible. Author

A93-35619
IGNITION ANALYSIS OF UNPREMIXED REACTANTS WITH CHAIN MECHANISM IN A SUPERSONIC MIXING LAYER
Y. JU and T. NIIOKA (Tohoku Univ., Sendai, Japan) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 863-868. refs
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Asymptotic analysis is performed to investigate the ignition of a viscous, two-dimensional and supersonic mixing layer of two parallel streams of oxidant and fuel. A three-step schematic kinetic model proposed by Birkan and Law is adopted to grasp the essential properties of full chemistry. Ignition is shown to be characterized by both thermal runaway and chain branching explosion. The lower branch of the characteristic S-shaped curve, corresponding to a nearly frozen regime, is produced by using the critical Damkoehler number of dimensionless ignition distance, which consists of Damkoehler numbers of chain branching reactions and that of chain termination reaction. The present results show that, in addition to the initial temperature difference of the two streams, the shear parameters and chemical kinetics have strong effects on ignition distance. Even when the velocity difference of two streams is not large, dissipation plays a dominant role as a heat source for ignition. With Mach number increase, ignition moves downstream at first, then reaches a turning point, and finally moves upstream. This analysis also shows that ignition distance will be greatly shortened with an increase of chainbranching reaction rates and will be delayed with an increase of chain termination rate. Author

N93-24890# British Aerospace Public Ltd. Co., Bristol (England). Research Centre.
A COMPUTATIONAL APPROACH TO PREDICTING THE EXTENT OF ARC ROOT DAMAGE IN CFC PANELS
NICHOLAS JENNINGS and C. JOHN HARDWICK (United Kingdom Atomic Energy Authority, Abingdon, England.) *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 8 p Nov. 1992 Sponsored in part by Rolls-Royce Ltd.; Construcciones Aeronauticas S.A.; Saab-Scania; Civil Aviation Authority; Dept. of Trade and Industry; and Short Bros. and Harland Ltd.
Avail: CASI HC A02/MF A03

It is important to understand the mechanism of lightning arc root damage to carbon fiber composite panels in view of their increasing use in airframe construction. A computer model has been developed which contains coupled models of current and heat flow and predicts the extent of panel damage. Both initial stroke and continuing current components can be modelled, and the CFC parameters may be temperature dependent. Results and some comparisons with observations are presented. Author

N93-24891# Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany).
COMPARISON OF THE DAMAGE FOR VARIOUS TYPES OF FIBRE REINFORCED COMPOSITES DUE TO DIFFERENT LIGHTNING TEST STANDARDS (MIL-STD-1757A, GERMAN MILITARY VG-STANDARD 96903)
JUERGEN WIEDMANN, JAN-UWE ROTH, and ALEXANDER W. KERN (Universitaet der Bundeswehr Muenchen, Neubiberg, Germany.) *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 16 p Nov. 1992 Sponsored by Ministry of Defence
Avail: CASI HC A03/MF A03

This paper provides experimental results on the extent and nature of damage on various types of aircraft FRC (fiber reinforced composites) caused by lightning arc attachment. Two different lightning test parameter sets were applied corresponding to MIL-STD-1757A and the German military VG-standard 96903 part 71. Concerning direct effects, the VG-standard differs from MIL-STD especially in the higher action integral (10 MJ/omega), the most important damage parameter with respect to FRC. Lightning tests with VG-standard are not known yet. The various types of tested aircraft FRC comprise unprotected and protected CFC and SFC/CFC-hybrid structures as well as novel, multilayered electromagnetic structures. The visible damage areas caused by impulse currents are strongly correlated to the action integrals. Metal protection meshes seem to suffer more from higher action integrals than the underlaying structures. The protection effectiveness of a new homogeneous protection system is proved. Author

N93-25843# Pratt and Whitney Aircraft, West Palm Beach, FL. Government Engines and Space Propulsion.
FATIGUE IN SINGLE CRYSTAL NICKEL SUPERALLOYS Technical Progress Report, 16 Dec. 1992 - 15 Jan. 1993
CHARLES ANNIS and DANIEL P. DELUCA 15 Jan. 1993 6 p
(Contract N00014-91-C-0124)
(AD-A260709; PW/GESP-FR-21988-15) Avail: CASI HC A02/MF A01

This program investigates the seemingly unusual behavior of single crystal airfoil materials. The fatigue initiation processes in single crystal (SC) materials are significantly more complicated and involved than fatigue initiation and subsequent behavior of a (single) macrocrack in conventional, isotropic materials. To understand these differences is the major goal of this project. DTIC

N93-25895# Army Materials Technology Lab., Watertown, MA.
HYDROGEN-INDUCED STRESS CORROSION CRACKING SUSCEPTIBILITY ANALYSIS OF PITCH LINKS FROM THE AH-64 APACHE HELICOPTER Final Report
PAUL BUCKLEY, MILTON LEVY, JOHN BEATTY, and RICHARD BROWN (Rhode Island Univ., Kingston.) Sep. 1992 19 p
(AD-A260692; MTL/TR-92-69) Avail: CASI HC A03/MF A01

AH-64 Apache helicopter pitch links were evaluated for degradation of mechanical properties due to service and susceptibility to hydrogen embrittlement. The pitch links were manufactured from 4340 electroslag remelted steel and heat treated to an HRC 52 hardness level and/or retempered to a HRC 38 hardness level and vacuum cadmium coated. Samples from fielded pitch links and virgin material were evaluated for comparison of mechanical behavior. Static torque-load tests on pitch links immersed in 3.5 percent NaCl at a potential of -1.2 V(SCE) were conducted for 1000 hours. Stress corrosion cracking resistance under hydrogen embrittlement conditions were determined. Mechanical and stress corrosion testing demonstrated no discernable change in properties due to service. Retempering the HRC 52 pitch links to HRC 38 resulted in properties similar to those expected from the 4340 ESR steel directly heat treated to the same hardness level. The immersion tests indicated no failure of the pitch links even at six times the service torque. The retempered material exhibited greater resistance to hydrogen-induced cracking. DTIC

N93-25902# Southwest Research Inst., San Antonio, TX. Belvoir Fuels and Lubricants Research Facility.
DEVELOPMENT OF A METHOD TO DETERMINE THE AUTOXIDATION OF TURBINE FUELS Final Report, Sep. 1987 - Apr. 1992
GEORGE E. FODOR and DAVID W. NAEGELI May 1992 255 p
(Contract N00014-87-K-2057)
(AD-A260578; BFLRF-280) Avail: CASI HC A12/MF A03

The report describes the development of a research grade test method that allows the precise evaluation of antioxidants and prediction of the rate of peroxide formation at ambient conditions from data obtained from accelerated oxidation experiments at elevated temperatures. The rates of peroxide formation in 10 model jet fuels were measured at several temperatures ranging from 43 to 120 C, with oxygen partial pressures ranging from approximately 10 to 1140 kPa. Results of rigorously controlled experiments agreed with a kinetic model of the autoxidation process, which showed that the peroxide concentration increased as the square of stress duration. Within the experimental limits, the rate of peroxide formation did not depend on the oxygen partial pressure. Arrhenius correlations of global rate constants determined from peroxide concentration time histories in accordance with the kinetic model showed that a single autoxidation was accountable for the results obtained in the 430 to 120 C temperature range. This method has also been used to evaluate the effectiveness of several hindered phenolic antioxidants to inhibit the formation of peroxides in two jet fuels at temperatures of 100 and 120 C and an oxygen partial pressure of 240 kPa (ca. 20 psig). Antioxidants were evaluated in terms of induction period duration and their rates of peroxide formation during the induction period and the initial linear segment of the post-induction time. The global rate constant for the formation of peroxides during the induction period was reduced by the antioxidant, whereas the post-induction rate remained unchanged. DTIC

N93-25914# Southwest Research Inst., San Antonio, TX. Belvoir Fuels and Lubricants Research Facility.
EFFECT OF A METAL DEACTIVATOR FUEL ADDITIVE ON FUEL DEPOSITION IN FUEL ATOMIZERS AT HIGH TEMPERATURE Interim Report, Nov. 1990 - Aug. 1992
CLIFFORD A. MOSES Aug. 1992 38 p
(Contract DAAK70-92-C-0059; DAAK70-87-C-0043)
(AD-A260915; BFLRF-281) Avail: CASI HC A03/MF A01

Fuel additives that are metal deactivators have been shown to improve the thermal stability breakpoint temperature of aviation fuels as determined in the Jet Fuel Thermal Oxidation Tester (JFTOT). These additives therefore, offer the opportunity to upgrade fuels of marginal thermal stability. However, concern has been expressed over whether this upgrade would be realized in actual aircraft hardware. To address this concern, an experimental project has been conducted with fuel atomizers from the T700 engine to determine the effect of the additive DMD-2, a metal deactivator, on high-temperature fuel deposition. The tests were conducted with JP-5 fuel supplied by the Naval Air Warfare Center Aircraft Division, Trenton (NAWCADTRN). For some of the tests, the base fuel was contaminated with copper to a concentration between 400 and 500 ppb. In the uncontaminated fuel, the metal deactivator (MDA) additive was tested at a concentration of 1 ppm; in the contaminated fuel, MDA concentrations of 1 ppm and 5.7 ppm were tested. With uncontaminated fuel, the results showed that initially the additive significantly reduced the deposition rate, but then, after an induction period, the deposition rate sharply increased. With the copper-contaminated fuel, at 1 ppm, the additive showed a small effect, but did not completely passivate the copper. At 5.7 ppm, there was no significant deposition during the test, indicating the copper was passivated. It is concluded that the metal deactivators inhibit deposition for a period of time until the surface becomes coated with carbon deposition, and then, they no longer serve any function. These results are consistent with some single-tube heat exchanger experiments reported in the literature. DTIC

N93-25948# California Univ., Irvine. Dept. of Mechanical and Aerospace Engineering.
FUNDAMENTAL STUDIES OF DROPLET INTERACTIONS IN DENSE SPRAYS Final Report, 1 Nov. 1989 - 31 Oct. 1992
W. A. SIRIGNANO, S. E. ELGHOBASHI, I. KIM, and C. H. CHIANG 31 Dec. 1992 136 p
(Contract AF-AFOSR-0064-90)
(AD-A261165; AFOSR-TR-93-0073) Avail: CASI HC A07/MF A02

The research addressed interactions amongst droplets in a dense spray. The effects of neighboring droplets, that were a few droplet diameters away, on a vaporizing droplet were examined by theoretical and computational analyses for two basic configurations: (1) the axisymmetric convective situation where two or three droplets moved in tandem and (2) the fully three-dimensional convective situation where droplets moved side-by-side. Droplets in the wake of other droplets experienced a reduction in drag force, transport rates, and vaporization rate, sometimes causing collisions. Sufficiently close droplets moving side-by-side, approximately in parallel, experienced a repulsive lift force and an increased drag force. Vaporizing liquid oxygen droplets in a hydrogen gas environment were studied at both subcritical and supercritical pressures considering the variable liquid density with the associated droplet swelling during heating and the dependence of the local critical state upon local composition. Droplet surface conditions could be subcritical even if pressures were supercritical for pure oxygen due to diffusing hydrogen. The critical surface regressed towards the droplet surface as the droplet heated. Engineering correlations for the drag coefficients, Nusselt numbers, and Sherwood numbers for hydrocarbon fuel droplets in dense sprays were obtained. DTIC

N93-26201*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXTERNAL STRESS-CORROSION CRACKING OF A 1.22-M-DIAMETER TYPE 316 STAINLESS STEEL AIR VALVE
THOMAS J. MOORE, JACK TELESMAN, ALLAN S. MOORE, DERECK F. JOHNSON, and DAVID E. KUIVINEN Washington Mar. 1993 21 p Original contains color illustrations
(Contract RTOP 505-62-84)
(NASA-TP-3190; E-6810; NAS 1.60:3190) Avail: CASI HC A03/MF A01; 7 functional color pages

An investigation was conducted to determine the cause of the failure of a massive AISI Type 316 stainless steel valve which controlled combustion air to a jet engine test facility. Several through-the-wall cracks were present near welded joints in the valve skirt. The valve had been in outdoor service for 18 years. Samples were taken in the cracked regions for metallographic and chemical analyses. Insulating material and sources of water mist in the vicinity of the failed valve were analyzed for chlorides. A scanning electron microscope was used to determine whether foreign elements were present in a crack. On the basis of the information generated, the failure was characterized as external stress-corrosion cracking. The cracking resulted from a combination of residual tensile stress from welding and the presence of aqueous chlorides. Recommended countermeasures are included. Author

N93-26268# CFD Research Corp., Huntsville, AL.
INFLUENCE OF SUPERCRITICAL CONDITIONS ON PRE-COMBUSTION CHEMISTRY AND TRANSPORT BEHAVIOR OF JET FUELS Final Report, 9 Jul. 1992 - 9 Jan. 1993
ANANTHA KRISHNAN Feb. 1993 60 p
(Contract F49620-92-C-0030)
(AD-A261813; CFDRC-4240/2; AFOSR-93-0137TR) Avail: CASI HC A04/MF A01

The objective of the Phase 1 study was to investigate heat transfer characteristics in supercritical flows. Detailed models were formulated to compute transport properties (such as density, conductivity, viscosity, and specific heat) in the supercritical regime. The models were incorporated into a general purpose Computational Fluid Dynamics (CFD) code capable of modeling flow, heat transfer, and reactions in complex geometries. Two and three-dimensional simulations were performed for supercritical flow and heat transfer in a test cell. Parallel experimental work was done by Professor L. D. Chen at the University of Iowa. The results of the Phase 1 work show that there is considerable augmentation of heat transfer near the critical point. Also, the large variation in density across the critical point has a significant effect on the near wall profiles of velocity and temperature. Ideal gas approximations of supercritical flows can result in gross errors in predicting heat transfer rates. The development of this supercritical transport model provides a basis for incorporating complex models for pre-combustion chemistry in jet fuels. DTIC

N93-26282# United Technologies Corp., West Palm Beach, FL.
FATIGUE IN SINGLE CRYSTAL NICKEL SUPERALLOYS Technical Progress Report
DANIEL P. DELUCA 16 Feb. 1993 6 p
(Contract N00014-91-C-0124)
(AD-A261742; FR21998-16) Avail: CASI HC A02/MF A01

This program investigates the seemingly unusual behavior of single crystal airfoil materials. The fatigue initiation processes in single crystal (SC) materials are significantly more complicated and involved than fatigue initiation and subsequent behavior of a (single) macrocrack in conventional, isotropic, materials. To understand these differences is the major goal of this project. DTIC

N93-26371# Naval Postgraduate School, Monterey, CA.
THERMALLY INDUCED STRESSES IN A COMPOSITE EXPOSED TO FIRE M.S. Thesis
EDWARD A. FAXLANGER, JR. Dec. 1992 98 p
(AD-A261714) Avail: CASI HC A05/MF A02

This thesis investigates the behavior of graphite/epoxy composites subjected to fire as may occur on the decks of naval aircraft carriers. The analytical model consists of two parts: one for the determination of the temperature field within the composite due to a fire, and the other for determining the stresses within the composite due to the temperature field. Both problems are provided one-dimensional finite element models. Appropriate failure criteria are incorporated to predict the survivability of composites in various fire environments. Parametric studies were performed and the results are presented in both graphical and tabular form. DTIC

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A93-33798
DELAMINATIONS OF BARELY VISIBLE IMPACT DAMAGE IN CFRP LAMINATES
PRASHANT KUMAR and BADRI RAI (Indian Inst. of Technology, Kanpur, India) Composite Structures (ISSN 0263-8223) vol. 23, no. 4 1993 p. 313-318. Research supported by Aeronautical Development Agency of India refs
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CFRP laminates were impacted by projectiles of low masses, accelerated in an air gun, to have barely visible impact damage (BVID) to simulate damage to aircraft by runway debris. The delamination damage on individual interfaces was revealed by the destructive method of thin strips. In sub-BVID and BVID specimens, the damage was confined mostly to the front 30 percent of the laminate thickness. Delamination areas in the BVID specimens were found to be considerable - the largest dimension exceeding 12 mm on several interfaces. Nucleation of delamination damage

was observed in interfaces adjacent to the mid plane in BVID specimens. At higher impact energies, about 110 to 150 percent more, the delamination damage was observed on almost all the interfaces with no sign of spalling at the rear surfaces. In comparison with a lightweight projectile of aluminum (4.4 g), a higher density steel projectile (11.8 g) caused more delamination damage for the same impact energy and an identical geometry of projectiles. Author

A93-33876* National Aeronautics and Space Administration, Washington, DC.
AIAA/ASME/ASCE/AHS/ASC STRUCTURES, STRUCTURAL DYNAMICS, AND MATERIALS CONFERENCE, 34TH AND AIAA/ASME ADAPTIVE STRUCTURES FORUM, LA JOLLA, CA, APR. 19-22, 1993, TECHNICAL PAPERS. PTS. 1-6
Washington American Institute of Aeronautics and Astronautics 1993 p. Pt. 1, 690 p.; pt. 2, 623 p.; pt. 3, 637 p.; pt For individual items see A93-33877 to A93-34242
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Topics addressed include the prediction of helicopter component loads using neural networks, spacecraft on-orbit coupled loads analysis, hypersonic flutter of a curved shallow panel with aerodynamic heating, thermal-acoustic fatigue of ceramic matrix composite materials, transition elements based on transfinite interpolation, damage progression in stiffened composite panels, a direct treatment of min-max dynamic response optimization problems, and sources of helicopter rotor hub inplane shears. Also discussed are dynamics of a layered elastic system, confidence bounds on structural reliability, mixed triangular space-time finite elements, advanced transparency development for USAF aircraft, a low-velocity impact on a graphite/PEEK, an automated mode-tracking strategy, transonic flutter suppression by a passive flap, a nonlinear response of composite panels to random excitation, an optimal placement of elastic supports on a simply supported plate, a probabilistic assessment of composite structures, a model for mode I failure of laminated composites, a residual flexibility approach to multibody dynamics,and multilayer piezoelectric actuators. AIAA

A93-33892#
A UNIFIED HYPERSONIC/SUPERSONIC METHOD FOR AEROELASTIC APPLICATIONS INCLUDING SHOCK-UNSTEADY WAVE INTERACTION
F. R. CHAVEZ and D. D. LIU (Arizona State Univ., Tempe) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 182-199. refs
(AIAA PAPER 93-1317) Copyright

A Perturbed Euler Characteristic method has been developed for unified hypersonic/supersonic flow over wedge or wedgelike profiles undergoing unsteady motion including panel vibrations of small amplitude. This method is valid for all Mach numbers ranging from the low-supersonic shock-attached limit to the Newtonian limit and for arbitrary body thickness. The method is completely general in the full-frequency range so long as the motion amplitude is small and the shock remains attached to the body apex. The method can fully account for the effect of unsteady Mach wave/shock wave interaction in the complete range of Mach number and reduced frequency. Three aeroelastic applications of the method are shown. AIAA

A93-33907# National Aeronautics and Space Administration, Washington, DC.
THERMOMECHANICAL POSTBUCKLING ANALYSIS OF LAMINATED COMPOSITE SHELLS
R. C. AVERILL (Michigan State Univ., East Lansing) and J. N. REDDY (Texas A & M Univ., College Station) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 351-360. refs
(Contract NGT-50404)
(AIAA PAPER 93-1337) Copyright

The nonlinear response of laminated composite structures subjected to thermal loads is investigated. Analysis is performed using a refined theory and an associated finite element model for geometrically nonlinear analysis of laminated composite shell structures. The model is based on a third-order displacement field which accounts for both transverse shear and transverse normal deformations. Numerical studies of simply-supported plates and cylindrical panels indicate that when the panels are free to expand or contract in the transverse direction, the predicted critical buckling temperatures do not depend significantly upon whether or not transverse normal deformations are explicitly accounted for in the analysis model. However, the critical buckling temperatures are strongly dependent upon whether or not the transverse normal deformations are restrained along the boundaries of the panels. Author

A93-33915*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DAMAGE PROGRESSION IN STIFFENED COMPOSITE PANELS
LEVON MINNETYAN, JAMES M. RIVERS (Clarkson Univ., Potsdam, NY), CHRISTOS C. CHAMIS, and PAPPU L. N. MURTHY (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 436-444. refs
(Contract NAG3-1101)
(AIAA PAPER 93-1345) Copyright

The design of composite structures requires an evaluation of their safety and durability under service loads and possible overload conditions. This paper presents a computational tool that has been developed to examine the response of stiffened composite panels via the simulation of damage initiation, growth, accumulation, progression, and propagation to structural fracture or co*lapse. The structural durability of a composite panel with a discontinuous stiffener is investigated under compressive loading induced by the gradual displacement of an end support. Results indicate damage initiation and progression to have significant effects on structural behavior under loading. Utilization of an integrated computer code for structural durability assessment is demonstrated. Author

A93-33916*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A HOT DYNAMIC SEAL RIG FOR MEASURING HYPERSONIC ENGINE SEAL DURABILITY AND FLOW PERFORMANCE
JEFFREY H. MILLER (Sverdrup Technology, Inc., Brook Park, OH), BRUCE M. STEINETZ (NASA, Lewis Research Center, Cleveland, OH), PAUL J. SIROCKY (Sverdrup Technology, Inc., Brook Park, OH), and LAWRENCE A. KREN (Case Western Reserve Univ., Cleveland, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 445-453. refs
(AIAA PAPER 93-1346) Copyright

A test fixture for measuring the dynamic performance of candidate high-temperature engine seal concepts has been installed at NASA Lewis Research Center. The test fixture has been designed to evaluate seal concepts under development for advanced hypersonic engines, such as those being considered for the National Aerospace Plane (NASP). The fixture can measure dynamic seal leakage performance from room temperature up to 840 C (1550 F) and air pressure differentials up to 690 kPa (100 psi). Performance of the seals can be measured while sealing against flat or distorted walls. In the fixture two seals are preloaded against the sides of a 30 cm (1 ft) long saber that slides transverse to the axis of the seals, simulating the scrubbing motion anticipated in these engines. This report covers the capabilities of this test

fixture along with preliminary data showing the dependence of seal leakage performance on high temperature cycling. Author

A93-33937#
STRUCTURAL MODELING OF LOW-ASPECT RATIO COMPOSITE WINGS
L. MEIROVITCH and T. J. SEITZ (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 652-662. refs
(AIAA PAPER 93-1371) Copyright

This paper is concerned with the aeroelastic tailoring of a structural model consisting of a rigid fuselage and a low-aspect ratio wing made of composite materials. The wing is modeled as a trapezoidal plate with root and tip chords parallel to the flow and with general sweep. The fuselage is capable of plunge and pitch and the elastic wing model includes shear deformations but ignores rotatory inertia. Author

A93-33960#
DAMAGE TOLERANCE EVALUATION OF NEW MANUFACTURING TECHNIQUES FOR COMPOSITE HELICOPTER DRIVE SHAFTS
PIERRE J. A. MINGUET (Boeing Defense and Space Group, Helicopters Div., Philadelphia, PA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 867-876. refs
(AIAA PAPER 93-1400) Copyright

Some potentially low-cost manufacturing techniques to produce composite drive shafts for helicopter dynamic systems are investigated. These include a tow-placement process for graphite/PEEK composite, filament-winding of graphite/PEEK and resin-transfer-molding of a two-dimensionally braided graphite fiber preform with two different resin systems, a standard epoxy and a toughened epoxy. Shaft specimens were based upon an existing helicopter shaft and sized for the same design requirements. Damage resistance to 'low-velocity' impact events typical of tool drops and part handling was determined using an instrumented impact machine. Damage in the form of delaminations was found in all specimens for energies as low as 2 ft-lb. A dynamic model of the impact event confirmed that high contact forces can develop during the impact because the high local stiffness of a cylindrical shell. Damage resistance results show that the tow-placed specimen and braided specimen with a toughened epoxy had the least amount of damage for a given impact. Specimens without and with impact damage were tested to ultimate torque. Results show that the towplaced thermoplastic shaft had the highest residual strength after impact. Author

A93-33962*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESPONSE OF LAMINATED COMPOSITE PLATES TO LOW-SPEED IMPACT BY AIRGUN-PROPELLED AND DROPPED-WEIGHT IMPACTORS
CHUNCHU B. PRASAD (Analytical Services and Materials, Inc., Hampton, VA), DAMODAR R. AMBUR, and JAMES H. STARNES, JR. (NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 887-900. refs
(AIAA PAPER 93-1402) Copyright

An analytical procedure has been developed to determine the transient response of simply supported, rectangular laminated composite plates subjected to impact loads from airgun-propelled or dropped-weight impactors. A first-order shear-deformation theory has been included in the analysis to represent properly any local short-wavelength transient bending response. The impact force has been modeled as a locally distributed load with a cosine-cosine distribution. A double Fourier series expansion and the Timoshenko small increment method have been used to determine the contact force, out-of-plane deflections, and inplane strains and stresses at any plate location due to an impact force at any plate location. The results of experimental and analytical studies are compared for quasi-isotropic laminates. The results indicate the importance of including transverse shear deformation effects in the analysis for predicting the response of laminated plates subjected to both airgun-propelled and dropped-weight impactors. The results also indicate that plate boundary conditions influence the axial strains more significantly than the contact force for a dropped-weight impactor. The results of parametric studies identify a scaling approach based on impactor momentum that suggests an explanation for the differences in the responses of plates impacted by airgun-propelled or dropped-weight impactors. Author

A93-33969#
LESSONS FROM APPLICATION OF EQUIVALENT PLATE STRUCTURAL MODELING TO AN HSCT WING
ELI LIVNE (Washington Univ., Seattle), ROBERT A. SELS, and KUMAR G. BHATIA (Boeing Commercial Airplane Group, Seattle, WA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 959-969. refs
(AIAA PAPER 93-1413) Copyright

Equivalent plate modeling practices are discussed in the context of application to a Boeing HSCT wing. Effects of using zones and effects of a wheel bay discontinuity are examined for classical plate theory (CPT) models. Results obtained reveal limitations of these models which appeared to be consistently stiffer than the corresponding finite element models and portray strong coupling between bending and torsional behavior. The equivalent plate models are inadequate for an HSCT wing because the wing does not have a high transverse shear stiffness. It is noted that a newly developed equivalent plate wing modeling capability based on first order shear deformation plate theory leads to better correlation with finite element results for the HSCT wing. AIAA

A93-33970#
AN AUTOMATED MODE TRACKING STRATEGY
T. TING (Bridgeport Univ., CT), T. L. C. CHEN, and W. J. TWOMEY (Sikorsky Aircraft, Stratford, CT) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 970-976. Research supported by Connecticut Dept. of Higher Education and Sikorsky Aircraft refs
(AIAA PAPER 93-1414) Copyright

A strategy based on a numerical problem involving modal correlation of a large-scale structure to determine the correct correspondence between the mode numbers and mode shapes of successive runs is presented. The strategy eliminated the need for complex mathematical treatments, requiring only two consecutive sets of eigenvectors from the corresponding analysis results. It is concluded that the proposed strategy is a practical and economical way of handling the mode crossing problem. AIAA

A93-33975*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WING FLUTTER BOUNDARY PREDICTION USING UNSTEADY EULER AERODYNAMIC METHOD
ELIZABETH M. LEE-RAUSCH and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers.

Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1019-1029. refs
(AIAA PAPER 93-1422) Copyright

Modifications to an existing 3D implicit upwind Euler/Navier-Stokes code for the aeroelastic analysis of wings are described. These modifications include the incorporation of a deforming mesh algorithm and the addition of the structural equations of motion for their simultaneous time-integration with the governing flow equations. The paper gives a brief description of these modifications and presents unsteady calculations which check the modifications to the code. Euler flutter results for an isolated 45 deg swept-back wing are compared with experimental data for seven freestream Mach numbers which define the flutter boundary over a range of Mach number from 0.499 to 1.14. These comparisons show good agreement in flutter characteristics for freestream Mach numbers below unity. For freestream Mach numbers above unity, the computed aeroelastic results predict a premature rise in the flutter boundary as compared with the experimental boundary. Steady and unsteady contours of surface Mach number and pressure are included to illustrate the basic flow characteristics of the time-marching flutter calculations and to aid in identifying possible causes for the premature rise in the computational flutter boundary. Author (revised)

A93-33978#
FINITE ELEMENT NONLINEAR RANDOM RESPONSE OF BEAMS TO ACOUSTIC AND THERMAL LOADS APPLIED SIMULTANEOUSLY

RUIXI CHEN and CHUH MEI (Old Dominion Univ., Norfolk, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1050-1060. refs
(Contract F33615-91-C-3205)
(AIAA PAPER 93-1427) Copyright

A finite element formulation combined with the equivalent linearization technique and the normal mode method is developed for the study of nonlinear random response of beams subjected to simultaneously applied acoustic and thermal loads. Examples include thermally buckled random response of simply supported beam, clamped-clamped beam and simply supported-clamped beam. To compare and validate the present formulation, results are compared with the solutions from existing sequential load method, and significant difference has been found. Results by classical continuum solution and the solution of Fokker-Planck-Kolmogorov equation are also derived and obtained for comparison. Author

A93-33999#
APPLICATION OF A P-VERSION FINITE ELEMENT CODE TO ANALYSIS OF CRACKS

A. F. LIU and J. J. GURBACH (Rockwell International Corp., Los Angeles, CA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 3 Washington American Institute of Aeronautics and Astronautics 1993 p. 1265-1273. refs
(AIAA PAPER 93-1450) Copyright

A commercially available finite element analysis computer package (the MECHANICA-APPLIED STRUCTURE) has been used to generate stress intensity solutions for structural damage tolerance analysis applications. A building block approach has been implemented in developing a data reduction technique for using the finite element code. Through two sets of numerical examples, it is demonstrated that stress intensity solutions for the center crack panels (2D), and the almond shaped cracks (3D), matched very well with known solutions available in the literature. Stress intensity factors were developed for complex structural geometries for which known stress intensity solutions did not exist. The accuracy of the finite element solutions for cracks (both 2D and 3D) in a cap-web specimen is demonstrated by correlating the analytically predicted and the experimentally generated crack growth histories. Author

A93-34022#
HAMMERHEAD AEROELASTIC STABILITY REVISITED

J. P. REDING and L. E. ERICSSON (Lockheed Missiles & Space Co., Inc., Sunnyvale, CA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 3 Washington American Institute of Aeronautics and Astronautics 1993 p. 1482-1492. refs
(AIAA PAPER 93-1477) Copyright

The paper considers the problem of the aeroelastic stability of hammerhead payloads and discusses the flow mechanism responsible for the critical cylinder length for hammerhead configurations. It is shown that, for short cylinder lengths, the upstream effects of the hammerhead wake are able to affect the terminal shock location, driving flow separation to the nose cylinder shoulder; this has the potential of causing aeroelastic instability leading to structural failure. The paper also discusses nose and nose-flare configuration effects with respect to their ability to cause flow separation and aeroelastic instability. AIAA

A93-34050#
ANALYSIS OF INTERLAMINAR STRESSES IN SYMMETRIC AND UNSYMMETRIC LAMINATES UNDER VARIOUS LOADINGS

C. A. LEGER (Lockheed Advanced Structures and Materials Group, Marietta, GA) and W. S. CHAN (Texas Univ., Arlington) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 3 Washington American Institute of Aeronautics and Astronautics 1993 p. 1770-1776. refs
(AIAA PAPER 93-1511) Copyright

A quasi-three-dimensional finite-element model is developed to investigate the interlaminar stresses in a composite laminate under combined loadings. An isoparametric quadrilateral element with eight nodes and three degrees of freedom per node is the finite element used in this study. The element is used to model a composite laminate cross section loaded by tension, torsion, transverse shear, and both beam and chord bending which are representative of loading in a helicopter rotor system. Symmetric and unsymmetric laminates are examined with comparisons made between the interlaminar stress distributions and magnitudes for each laminate. Unsymmetric results are compared favorably to limited results found in literature. The unsymmetric interlaminar normal stress distribution in a symmetric laminate containing a free edge delamination is also examined. Author

A93-34073#
A REFINED STRUCTURAL MODEL OF COMPOSITE AIRCRAFT WINGS FOR THE ENHANCEMENT OF VIBRATIONAL AND AEROELASTIC RESPONSE CHARACTERISTICS

L. LIBRESCU, L. MEIROVITCH, and O. SONG (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 1967-1978. refs
(Contract AF-AFOSR-91-0351)
(AIAA PAPER 93-1536) Copyright

This paper presents an analytical study of the vibrational and static aeroelastic response of anisotropic composite aircraft wings modeled as thin-walled beams. To this end, a response beam model incorporating a number of important effects essential for a reliable prediction of wing response characteristics is developed. The implications of the bending-twist structural coupling induced by the ply-angle distribution are examined and the power of the

tailoring technique toward enhancing the dynamic and static structural characteristics is revealed. Author

A93-34076#
CALCULATION OF NUMERICAL BOUNDARY MEASURE FOR WAVELET-GALERKIN APPROXIMATIONS IN AEROELASTICITY
JEONGHWAN KO, ANDREW J. KURDILA, SANG-YOUNG PARK, and THOMAS STRGANAC (Texas A & M Univ., College Station) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 2009-2019. Research supported by Texas A & M Univ. refs
(Contract F49620-92-J-0450)
(AIAA PAPER 93-1539) Copyright

Wavelet analysis is regarded as an extremely promising tool for approximate solution of multi-field problems, such as those arising in aeroelasticity and fluid structure interaction, due to its inherent multiresolution/multi-scale nature. However, wavelet analysis has been conducted primarily within the fields of signal and image processing due to the difficulty in defining wavelet bases that satisfy specified boundary conditions. This paper employs an embedded domain technique to ameliorate the difficulty associated with deriving a wavelet basis for a specific multi-field initial/boundary value problem. Instead of constructing an explicit wavelet basis over the domain of interest, boundary conditions are enforced using a penalty formulation that requires the calculation of a numerical boundary measure. This paper presents strategies for the rapid calculation of numerical boundary measures employed in wavelet-Galerkin approximations of problems in aeroelastic transient response and control. In addition, the impact of new wavelet quadrature truncation error bounds is discussed in the context of aeroelastic simulation and control. Author

A93-34077*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN INVERSE METHOD FOR COMPUTATION OF STRUCTURAL STIFFNESS DISTRIBUTIONS OF AEROELASTICALLY OPTIMIZED WINGS
DAVID M. SCHUSTER (Lockheed Engineering and Sciences Co., Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 2020-2027. refs
(Contract NAS1-19000)
(AIAA PAPER 93-1540) Copyright

An inverse method has been developed to compute the structural stiffness properties of wings given a specified wing loading and aeroelastic twist distribution. The method directly solves for the bending and torsional stiffness distribution of the wing using a modal representation of these properties. An aeroelastic design problem involving the use of a computational aerodynamics method to optimize the aeroelastic twist distribution of a tighter wing operating at maneuver flight conditions is used to demonstrate the application of the method. This exercise verifies the ability of the inverse scheme to accurately compute the structural stiffness distribution required to generate a specific aeroelastic twist under a specified aeroelastic load. Author

A93-34102*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STIFFNESS, THERMAL EXPANSION, AND THERMAL BENDING FORMULATION OF STIFFENED, FIBER-REINFORCED COMPOSITE PANELS
CRAIG S. COLLIER (Lockheed Engineering & Sciences Co.; NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 2279-2290. refs
(Contract NAS1-19000)
(AIAA PAPER 93-1569)

A method is presented for formulating stiffness terms and thermal coefficients of stiffened, fiber-reinforced composite panels. The method is robust enough to handle panels with general cross sectional shapes, including those which are unsymmetric and/or unbalanced. Nonlinear, temperature and load dependent constitutive material data of each laminate are used to 'build-up' the stiffened panel membrane, bending, and membrane-bending coupling stiffness terms and thermal coefficients. New thermal coefficients are introduced to quantify panel response from through-the-thickness temperature gradients. A technique of implementing this capability with a single plane of shell finite elements using the MSC/NASTRAN analysis program (FEA) is revealed that provides accurate solutions of entire airframes or engines with coarsely meshed models. An example of a composite, hat-stiffened panel is included to demonstrate errors that occur when an unsymmetric panel is symmetrically formulated as traditionally done. The erroneous results and the correct ones produced from this method are compared to analysis from discretely meshed three-dimensional FEA. Author (revised)

A93-34113#
AN EFFECTIVE MIXED ANNEALING/HEURISTIC ALGORITHM FOR PROBLEMS IN KINEMATIC MECHANICAL DESIGN
MADARA M. OGOT and SATNAM S. ALAG (Rutgers Univ., Piscataway, NJ) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 4 Washington American Institute of Aeronautics and Astronautics 1993 p. 2389-2401. refs
(AIAA PAPER 93-1581) Copyright

The wide application of stochastic optimization methods in mechanical design has been partially hindered due to (a) the relatively long computation time required, and (b) discretization of the design space at the onset of the optimization process. This work proposes a new stochastic algorithm, the Mixed Annealing/Heuristic Algorithm (MAH), which addresses both these issues. It is based on the Simulated Annealing algorithm (SA) and the Heuristic Optimization Technique (HOT). Both these algorithms have been successfully applied to problems in mechanical design and up to now have been considered as competing algorithms. MAH capitalizes on each of their individual strengths and addresses their weaknesses, thereby considerably reducing the computational effort required to attain the final solution. A pseudo-continuous approach for configuration generation is employed, making the discretization of the design space no longer necessary. The effectiveness of MAH is demonstrated via three problems in kinematic synthesis. Comparison of the results with other stochastic optimization methods illustrates the potential of this technique. Author

A93-34130#
NONLINEAR AEROELASTIC RESPONSE OF PANELS
ROBERT R. REYNOLDS and EARL H. DOWELL (Duke Univ., Durham, NC) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2566-2576. Research supported by North Carolina Supercomputing Center refs
(AIAA PAPER 93-1599) Copyright

We consider the nonlinear aeroelastic response of panels supported by an elastic foundation in subsonic and supersonic flows. A two-dimensional, simply supported panel with an elastic foundation in subsonic flow is studied using a linear stability analysis (including postbuckled behavior) and numerical integrations of the full nonlinear equations of motion. It is shown that a panel in incompressible, subsonic flow can oscillate aperiodically. However, when structural damping is included in the model, the response diverges rather than flutters and becomes statically and dynamically stable in a buckled shape at all higher flow velocities. The results

of numerical studies of a panel in supersonic flow are also presented including a fractal dimension estimate of the chaotic attractor. As is well known, only flutter occurs at high Mach numbers and sufficiently large dynamics pressures. This flutter, however, can be periodic or chaotic. The dimension of the spatiotemporal chaos for this aeroelastic system is shown to be low (less than 3). Author

A93-34157# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DYNAMICS OF ROTATING MULTICOMPONENT TURBOMACHINERY SYSTEMS
CHARLES LAWRENCE (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2836-2847. Previously announced in STAR as N93-18426 refs
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(AIAA PAPER 93-1629) Copyright

The ultimate objective of turbomachinery vibration analysis is to predict both the overall, as well as component dynamic response. To accomplish this objective requires complete engine structural models, including multistages of bladed disk assemblies, flexible rotor shafts and bearings, and engine support structures and casings. In the present approach each component is analyzed as a separate structure and boundary information is exchanged at the inter-component connections. The advantage of this tactic is that even though readily available detailed component models are utilized, accurate and comprehensive system response information may be obtained. Sample problems, which include a fixed base rotating blade and a blade on a flexible rotor, are presented. Author

A93-34169*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NEW SENSITIVITY ANALYSIS FOR STRUCTURAL OPTIMIZATION OF COMPOSITE ROTOR BLADES
C. VENKATESAN, P. P. FRIEDMANN, and KUO-AN YUAN (California Univ., Los Angeles) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2952-2973. refs
(Contract NAG1-833)
(AIAA PAPER 93-1644) Copyright

This paper presents a detailed mathematical derivation of the sensitivity derivatives for the structural dynamic, aeroelastic stability and response characteristics of a rotor blade in hover and forward flight. The formulation is denoted by the term semianalytical approach, because certain derivatives have to be evaluated by a finite difference scheme. Using the present formulation, sensitivity derivatives for the structural dynamic and aeroelastic stability characteristics, were evaluated for both isotropic and composite rotor blades. Based on the results, useful conclusions are obtained regarding the relative merits of the semi-analytical approach, for calculating sensitivity derivatives, when compared to a pure finite difference approach. Author

A93-34170*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSITIVITY ANALYSIS OF AEROELASTIC RESPONSE OF A WING USING PIECEWISE PRESSURE REPRESENTATION
LLOYD B. ELDRED, RAKESH K. KAPANIA (Virginia Polytechnic Inst. and State Univ., Blacksburg), and JEAN-FRANCOIS M. BARTHELEMY (NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2974-2984. refs
(Contract NAS1-18471; NAG1-1411)
(AIAA PAPER 93-1645) Copyright

A sensitivity analysis scheme of the static aeroelastic response of a wing is developed, by incorporating a piecewise panel-based pressure representation into an existing wing aeroelastic model to improve the model's fidelity, including the sensitivity of the wing static aeroelastic response with respect to various shape parameters. The new formulation is quite general and accepts any aerodynamics and structural analysis capability. A program is developed which combines the local sensitivities, such as the sensitivity of the stiffness matrix or the aerodynamic kernel matrix, into global sensitivity derivatives. AIAA

A93-34171*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSITIVITY ANALYSIS OF FLUTTER RESPONSE OF A TYPICAL SECTION AND A WING IN TRANSONIC FLOW
RAKESH K. KAPANIA, JASON C. ISSAC (Virginia Polytechnic Inst. and State Univ., Blacksburg), and JEAN-FRANCOIS M. BARTHELEMY (NASA, Langley Research Center, Hampton, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2985-2997. refs
(Contract NAG1-1411)
(AIAA PAPER 93-1646) Copyright

A sensitivity analysis of flutter response of a two-degree of freedom airfoil with plunging and pitching degrees of freedom in transonic flow was performed using a state-space representation of the unsteady aerodynamic behavior. The structural equations of motion of the airfoil with bending and torsional degrees of freedom are coupled to the unsteady airloads, and the aeroelastic system so modeled is solved as an eigenvalue problem to determine the stability. The results of eigenanalysis showed good agreement with flutter calculations performed using a time-integration of the aeroelastic equations. The sensitivities of the flutter speed with respect to the mass and stiffness parameters wee computed by both the analytical and finite difference methods, showing excellent agreement. AIAA

A93-34172*# National Aeronautics and Space Administration, Washington, DC.
RECENT DEVELOPMENTS IN EQUIVALENT PLATE MODELING FOR WING SHAPE OPTIMIZATION
ELI LIVNE (Washington Univ., Seattle) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 5 Washington American Institute of Aeronautics and Astronautics 1993 p. 2998-3011. Research supported by NASA refs
(AIAA PAPER 93-1647) Copyright

A new technique for structural modeling of airplane wings is presented taking transverse shear effects into account. The kinematic assumptions of first order shear deformation plate theory in combination with numerical analysis based on simple polynomials which define geometry, construction and displacement approximations lead to analytical expressions for elements of the stiffness and mass matrices and load vector. Contributions from the cover skins, spar and rib caps and spar and rib webs are included as well as concentrated springs and concentrated masses. Limitations of current equivalent plate wing modeling techniques based on classical plate theory are discussed, and the improved accuracy of the new equivalent plate technique is demonstrated through comparison to finite element analysis and test results. Analytical derivatives of stiffness, mass and load terms with respect to wing shape lead to analytic sensitivities of displacements, stresses and natural modes with respect to planform shape and depth distribution. This makes the new capability an effective structural tool for wing shape optimization. Author

A93-34191*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PROBABILISTICALLY CONFIGURED ADAPTIVE COMPOSITE STRUCTURES
MICHAEL C. SHIAO (Sverdrup Technology, Inc., Brook Park, OH) and CHRISTOS C. CHAMIS (NASA, Lewis Research Center, Cleveland, OH) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 6 Washington American Institute of Aeronautics and Astronautics 1993 p. 3198-3208. refs
(AIAA PAPER 93-1679) Copyright

A composite wing with spars, bulkheads and built-in sensor/control devices is probabilistically configured with a methodology for the probabilistic assessment of smart composite structures. Structural responses such as changes in angle of attack, vertical displacements and stresses in the non-control and control plies are probabilistically assessed to quantify their respective scatter ranges. Sensitivity factors are evaluated to identify those parameters that have the greatest influence on a specific structural response. Results show that smart composite structures can be configured to control distortions and ply stresses, and to have specified scatter ranges in the frequencies, buckling loads in the presence of defects to satisfy specified design requirements. Author

A93-34224#
ACTIVE CONSTRAINED LAYER VISCOELASTIC DAMPING
GREGORY S. AGNES (USAF, Wright Lab., Wright-Patterson AFB, OH) and KEVIN NAPOLITANO (CSA Engineering, Inc., Palo Alto, CA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 6 Washington American Institute of Aeronautics and Astronautics 1993 p. 3499-3506. refs
(AIAA PAPER 93-1702)

Vibration is a significant problem for aircraft. One common solution to vibration problems is to increase the modal damping through viscoelastic constrained layer treatments. An investigation into the use of an active constraining layer in place of a traditional constrained layer damping treatment is presented. Models, both analytical and finite element, were formed. Modal damping increases significantly for the fundamental mode of a simply supported beam. The effectiveness of the treatment is good over a broader temperature range as well. Active constraining layers can therefore reduce the resonant structural response of aircraft systems. Author

A93-34239
DYNAMICS OF A HIGH SPEED IMPELLER - ANALYSIS AND EXPERIMENTAL VERIFICATION
F. K. STRAUB, H. NGO, L. J. SILVERTHORN, and J. A. RUOPSA (McDonnell Douglas Helicopter Co., Mesa, AZ) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 6 Washington American Institute of Aeronautics and Astronautics 1993 p. 3651-3660. refs
(AIAA PAPER 93-1362) Copyright

Centrifugal compressors are used on numerous aircraft as an efficient and lightweight source of air. The impeller is the key compressor component, both from an aerodynamic and structural dynamics point of view. The present paper investigates the structural dynamics of the blades of a particular impeller, using analytical and experimental methods. Correlation of results show good agreement. The analytical model is then used for design studies to improve the fatigue life of the impeller blades. Author

A93-34259
TAPERED GEOMETRIES FOR IMPROVED CRASHWORTHINESS UNDER SIDE LOADS
DAVID C. FLEMING and ANTHONY J. VIZZINI (Maryland Univ., College Park) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38. no. 1 Jan. 1993 p. 38-44. refs
(Contract DAAL03-88-C-0002)
Copyright

Truncated cones of varying degrees of taper are manufactured from unidirectional AS4/3501-6 graphite/epoxy preimpregnated tape and are loaded in compression. Different amounts of side loads are introduced by orienting the loading axis away from the central axis of the cone. The energy absorption properties of the cones are measured under quasistatic conditions. The failure modes are determined around the circumference as a function of the loading and taper angles, and the energy absorbency is correlated to the observed failure modes. Constant crosssection specimens suffer significant losses in energy absorption in the presence of side loads; however, tapered specimens are less sensitive and do not suffer such significant losses. In fact, tapered geometries provide greater energy absorption than constant crosssection geometries at moderate levels of side loads. Author

A93-34261
DYNAMIC ANALYSIS OF ROTOR FLEXBEAMS BASED ON NONLINEAR ANISOTROPIC SHELL MODELS
OLIVIER A. BAUCHAU and WUYING CHIANG (Rensselaer Polytechnic Inst., Troy, NY) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38. no. 1 Jan. 1993 p. 55-61. AHS International Specialists' Meeting on Rotorcraft Basic Research, Atlanta, GA, Mar. 25-27, 1991, Proceedings, p. 21-1 to 21-11. Previously cited in issue 19, p. 3367, Accession no. A92-46946 Research supported by Chung Shan Inst. of Science and Technology refs
Copyright

A93-34287
AN OPTICAL FIBER BASED POSITION SENSOR WITH IMMUNITY TO TEMPERATURE VARIATION
S. CHEN, B. T. MEGGITT, A. W. PALMER, and K. T. V. GRATTAN (City Univ., London, United Kingdom) *In* Controls for optical systems; Proceedings of the Meeting, Orlando, FL, Apr. 21, 22, 1992 Bellingham, WA Society of Photo-Optical Instrumentation Engineers 1992 p. 153-159. Research supported by SERC refs
Copyright

This paper presents a position monitoring system incorporating high birefringent optical fiber and white-light interferometry, where the measurement process takes place within the optical fiber medium. With a novel scheme of relative position detection, the effects of temperature variation can be largely eliminated. A position monitoring range of 200 mm, accuracy of about 3 mm with temperature stability to within less than 0.5 percent was experimentally demonstrated. Author (revised)

A93-34301* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL METHODS IN LAMINAR AND TURBULENT FLOW; PROCEEDINGS OF THE 7TH INTERNATIONAL CONFERENCE, STANFORD UNIV., CA, JULY 15-19, 1991. VOL. 7, PTS. 1 & 2
C. TAYLOR, ED. (Swansea, Univ. College, United Kingdom), J. H. CHIN, ED. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), and G. M. HOMSY, ED. Swansea, United Kingdom Pineridge Press 1991 p. Pt. 1, 857 p.; pt. 2, 932 p. For individual items see A93-34302 to A93-34374
(ISBN 0-906674-77-8) Copyright

Consideration is given to the impulse response of a laminar boundary layer and receptivity; numerical transition to turbulence in plane Poiseuille flow; large eddy simulation of turbulent wake flow; a viscous model and loss calculation of a multisplitter cascade; vortex initiation during dynamic stall of an airfoil; a numerical analysis of isothermal flow in a combustion chamber; and compressible flow calculations with a two-equation turbulence model and unstructured grids. Attention is also given to a 2D calculation of a buoyant flow around a burning sphere, a fast multigrid method for 3D turbulent incompressible flows, a streaming

flow induced by an oscillating cascade of circular cylinders, an algebraic multigrid scheme for solving the Navier-Stokes equations on unstructured meshes; and nonlinear coupled multigrid solutions to thermal problems employing different nodal grid arrangements and convective transport approximations. AIAA

A93-34311* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
TURBULENCE AND STALL IN PLANE DIFFUSERS - COMPUTATIONAL STUDY
A. O. DEMUREN (Old Dominion Univ., Norfolk, VA) *In* Numerical methods in laminar and turbulent flow; Proceedings of the 7th International Conference, Stanford Univ., CA, July 15-19, 1991. Vol. 7, pt. 1 Swansea, United Kingdom Pineridge Press 1991 p. 179-188. refs
(Contract NASA ORDER C-99066-G)
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The effect of free-stream turbulence level on stall conditions in plane diffusers is investigated with a finite-volume numerical method which utilizes a k-epsilon turbulence model or a differential Reynolds stress model for closure. Computed results show qualitative agreement with measured data. The ability to eliminate stall and thereby increase pressure recovery in diffusers at large included angles by utilizing high free-stream turbulence is correctly predicted. Author (revised)

A93-34469
COMANCHE AIRFRAME DESIGN - THE PDT APPROACH
BRUCE F. KAY (Sikorsky Aircraft, Stratford, CT) Aerospace America (ISSN 0740-722X) vol. 31, no. 4 April 1993 p. 22-24.
Copyright

The paper discusses the product development team (PDT) management approach adopted for the airframe design of the RAH-66 Comanche, a new helicopter for armed reconnaissance. One of the Comanche program's most important goals is cost control, and mechanisms for accomplishing this are firmly imbedded in all PDTs. Continuous evaluation of the supportability attributes is performed by PDT members representing different areas. Typical of the analyses used to influence the design is the predictions of maintenance requirements. These data are used, for example, to determine equipment locations; components requiring the most maintenance are placed in the most accessible positions. AIAA

A93-34472
DEVELOPING THE MD EXPLORER
PHILIP V. HOWIE (McDonnell Douglas Helicopter Co., Mesa, AZ) Aerospace America (ISSN 0740-722X) vol. 31, no. 4 April 1993 p. 31-34.
Copyright

The MD Explorer is an eight-seat twin-turbine engine helicopter which is being developed using integrated product definition (IPD) team methodology. New techniques include NOTAR antitorque system for directional control, a composite fuselage, an all-composite bearingless main rotor, and digital cockpit displays. Three-dimensional CAD models are the basis of the entire Explorer design. Solid models provide vendor with design clarification, removing much of the normal drawing interpretation errors. AIAA

A93-34476
NUMERICAL SIMULATION OF TURBINE 'HOT SPOT' ALLEVIATION USING FILM COOLING
DANIEL J. DORNEY and ROGER L. DAVIS (United Technologies Research Center, East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 329-336. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3309. Previously cited in issue 20, p. 3551, Accession no. A92-48896 Research supported by United Technologies Corp. refs
(Contract N00014-88-C-0677)
Copyright

A93-34496 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL SUPERSONIC HYDROGEN COMBUSTION EMPLOYING STAGED INJECTION BEHIND A REARWARD-FACING STEP
JOHN D. ABBITT, III, CORIN SEGAL (Florida Univ., Gainesville), JAMES C. MCDANIEL, ROLAND H. KRAUSS, and ROBERT B. WHITEHURST (Virginia Univ., Charlottesville) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 3 May-June 1993 p. 472-478. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0090. Previously cited in issue 07, p. 1052, Accession no. A92-22196 refs
(Contract NAG1-795; NGT-50142)
Copyright

A93-34847
WALL JETS CREATED BY SINGLE AND TWIN HIGH PRESSURE JET IMPINGEMENT
P. MILLER and M. WILSON (Miller and Wilson Aerodynamics Research, Bath, United Kingdom) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 963 March 1993 p. 87-100. Research supported by British Aerospace, PLC refs
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An extensive experimental investigation into the nature of the wall jets produced by single and twin normal jet impingement has been undertaken. Wall jet velocity profiles have been recorded up to 70 jet diameters from the impingement point, at pressures representative of current VStol technology. The tests used fixed convergent nozzles, with nozzle height and spacing and jet pressure being varied. Single jet impingement displays a consistent effect of nozzle height on wall jet development. For twin jet cases a powerful reinforcement exists along the wall jet interaction plane. Remote from the interaction plane the wall jets are weaker than those produced by a single jet impingement. Author

A93-34925
MEASUREMENTS OF WEAR AND ACOUSTIC EMISSION FROM FUEL-WETTED SURFACES
R. J. BONESS (Royal Military College of Canada, Kingston) Wear (ISSN 0043-1648) vol. 162-164, pt. B April 13, 1993 p. 703-705. Wear of materials; Proceedings of the 9th International Conference, San Francisco, CA, Apr. 13-16, 1993. A93-34901 13-37 refs
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This paper is concerned with the measurement and subsequent analysis of acoustic emission (AE) signals obtained during the wear testing of steel surfaces lubricated by Jet A-1 fuel. The results show that AE rms signals can detect different wear processes occurring in air and nitrogen atmospheres. Further wear test studies of commercially available Jet A-1 fuel and clay-treated Jet A-1 fuel, in nitrogen, indicate that AE rms signals can identify the critical load at which gross failure, or scuffing of the test surfaces, occurs. Consequently, AE measurements are able to detect the presence of wear-reducing additives. Author

A93-35178#
COMPUTATION OF AEROELASTIC CHARACTERISTICS AND STRESS-STRAINED STATE OF PARACHUTES
IGOR' V. DNEPROV (Scientific-Research Inst. of Parachute Constructions, Moscow, Russia) *In* RAeS/AIAA Aerodynamic Decelerator Systems Technology Conference and Seminar, 12th, London, United Kingdom, May 10-13, 1993, Technical Papers Washington American Institute of Aeronautics and Astronautics 1993 p. 240-244. refs
(AIAA PAPER 93-1237) Copyright

The paper presents computation results of the stress-strained state and aeroelastic characteristics of different types of parachutes in the process of their interaction with a flow. Simulation of the aerodynamic part of the aeroelastic problem is based on the discrete vortex method, while the elastic part of the problem is solved by employing either the finite element method, or the finite difference method. The research covers the following problems of

the axisymmetric parachutes dynamic aeroelasticity: parachute inflation, forebody influence on the aerodynamic characteristics of the object-parachute system, parachute disreefing, parachute inflation in the presence of the engagement parachute. The paper also presents the solution of the spatial problem of static aeroelasticity for a single-envelope ram-air parachute. Some practical recommendations are suggested. Author (revised)

A93-35276
ENSURING THE RELIABILITY AND SERVICE LIFE OF FLIGHT VEHICLE STRUCTURES BY ENGINEERING METHODS [OBESPECHENIE NADEZHNOSTI I RESURSA KONSTRUKTSII LA TEKHNOLOGICHESKIMI METODAMI]
A. I. IARKOVETS, ED. Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 90 p. In Russian. For individual items see A93-35277 to A93-35296

The papers presented in this volume deal with the various aspects of the manufacture of flight vehicles. In particular, attention is given to ways of increasing the service life and reliability of bolted joints, some changes in methods for calculating fatigue strength characteristics, a method for estimating the survivability of bodies of revolution, and the stress-strain state of the elements of a single-stringer riveted panel. Other topics discussed include the effect of overloads on the service life of the structural elements of aircraft, methods of increasing the load-bearing capacity of welded structures, and selection of a method for sealing riveted joints in fuel compartments. AIAA

A93-35277
SINGLE-IMPACT CALIBRATED ELECTROMAGNETIC TIGHTENING OF LONG-LIFE BOLTED JOINTS IN AVIATION STRUCTURES [ODNOUDARNAIA TARIROVANNAIA ELEKTROMAGNITNAIA ZATIAZHKA VYSOKORESURSNYKH BOLTOVYKH SOEDINENII V AVIATSIONNYKH KONSTRUKTSIIAKH]
V. A. FIRSOV and V. I. BEKHMET'EV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 4-8. In Russian. refs

The general design and operation of a newly developed electromagnetic impact driver for the assembly of aviation structures is described. The electromagnetic impact driver makes it possible to considerably improve the precision of bolt torquing during the assembly. To test the performance of the new tool, M6 bolts of 16KhSN steel (tensile strength 120 +/- 10 kg/sq mm) were tightened by a manual torque wrench and by the electromagnetic impact driver. It is shown that the scatter of bolt elongation during the tightening by the impact driver is a factor of 3-5 less than in the case of manual torquing, which corresponds to a torque precision of 1.5-2 percent. AIAA

A93-35278
EFFECT OF A COMBINATION OF DESIGN AND PROCESS-RELATED FACTORS ON THE FATIGUE STRENGTH OF BOLTED JOINTS IN ACOUSTICALLY LOADED AIRCRAFT STRUCTURES [VLIIANIE KOMPLEKSA KONSTRUKTIVNO-TEKHNOLOGICHESKIKH FAKTOROV NA USTALOSTNUIU DOLGOVECHNOST' BOLTOVYKH SOEDINENII, RABOTAIUSHCHIKH NA AKUSTICHESKOM NAGRUZHENII KONSTRUKTSII LA]
V. I. BEKHMET'EV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 8-11. In Russian. refs

The effect of several factors related to the design and assembly of bolted joints (e.g., torque, radial stress, axial pressing force, and the difference of the angles of the countersunk hole and of the conical head of the bolt) on the stress-strain state and the fatigue strength of concealed bolted joints in aircraft structures exposed to acoustic loading is investigated analytically. It is shown how the results of fatigue tests can be used to select the proper parameters of the assembly of bolted joints for acoustically loaded structures. AIAA

A93-35281
WAYS OF INCREASING THE SERVICE LIFE AND RELIABILITY OF BOLTED JOINTS [PUTI POVYSHENIIA RESURSA I NADEZHNOSTI BOLTOVYKH SOEDINENII]
V. V. GURETSKII and G. L. BUACHIDZE *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 20-22. In Russian.

Possible ways of increasing the service life and reliability of bolted joints are examined with particular reference to results obtained for a flange bolt used in a commercially produced aircraft. Based on the results of the analysis, it is shown that the reliability and service life of bolted joints can be increased by: (1) using tighter tolerances on parts; (2) allowing for the scatter of parameter values for critical parts; and (3) practicing rigorous quality control during production. AIAA

A93-35283
HIGH-STRENGTH COMBINATION FASTENERS FOR JOINT ASSEMBLY IN AIRCRAFT STRUCTURES [KOMBINIROVANNYI VYSOKOPROCHNYI KREPEZH DLIA VYPOLNENIIA SOEDINENII V AVIATSIONNYKH KONSTRUKTSIIAKH]
S. L. VASIL'EV, V. F. GROMOV, M. L. LIAPUNOV, and IU. V. MASLOV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 28-31. In Russian.

Two new titanium alloy rivet designs intended for the assembly of the aluminum structures of wide-body aircraft are described. One type of rivet consists of a bushing of VT16 titanium alloy and a pin of V65 alloy. The other rivet is a three-element design consisting of a pin with two end cavities filled with inserts of V65 alloy. The new rivets make it possible to produce high-strength joints using automatic equipment and can be used instead of bolt-rivets of titanium alloys. AIAA

A93-35286
MATHEMATICAL STATEMENT OF THE PROBLEM OF OPTIMIZING THE DESIGN OF AN AIRFRAME FOR EASE OF MANUFACTURE [MATEMATICHESKAIA POSTANOVKA ZADACHI OTRABOTKI NA TEKHNOLOGICHNOST' KONSTRUKTSII UZLA PLANERA LA]
A. G. GROMASHEV and N. M. KISELEV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 37-43. In Russian.

The use of computers for solving the problem of geometrical compatibility between the component to be manufactured and the process equipment used makes it possible to interactively solve the problem of the accessibility of mechanical joints at the design stage. At this stage, the geometry of the joint area can be modified to ensure its accessibility, and the types of tools and equipment that are particularly suitable for producing a given mechanical joint can be specified in the technical documentation. Here, this problem is formulated mathematically, and the mathematical model is demonstrated for a structural element of an airframe. AIAA

A93-35287
A METHOD FOR ESTIMATING THE SURVIVABILITY OF BODIES OF REVOLUTION [METODIKA OTSENKI ZHIVUCHESTI TEL VRASHCHENIIA]
V. B. BOITSOV, E. V. KOLESNIKOV, and V. V. TULIAKOV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 43-46. In Russian.

A numerical method is developed for predicting the propagation of fatigue cracks in aircraft structures in the framework of linear fracture mechanics. The algorithm for estimating the period of fatigue crack growth is implemented in computer software designed specifically for bodies of revolution. As an example, the program is used to predict fatigue crack propagation in a bolted joint. AIAA

A93-35288
STRESS-STRAIN STATE OF THE ELEMENTS OF A SINGLE-STRINGER RIVETED PANEL [NAPRIAZHENNO-DEFORMIROVANNOE SOSTOIANIE ELEMENTOV ODNOSTRINGERNOI PANELI KLEPANOI KONSTRUKTSII]
A. I. IARKOVETS, S. L. VASIL'EV, V. F. GROMOV, M. L. LIAPUNOV, and IU. V. MASLOV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 46-50. In Russian.
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The stress-strain state of riveted single-stringer panels induced during the riveting operation was investigated experimentally as a function of the riveting sequence. In the experiment, the assembly of single-stringer panels (2000x150 mm), with a skin of D16ATI.6 alloy and a stringer of D16ChT alloy, was carried out using several different riveting routes. It is shown that, by selecting an optimal riveting route, it is possible to reduce the residual deflections of the panel by 30-40 percent. AIAA

A93-35289
EFFECT OF OVERLOADS ON THE SERVICE LIFE OF THE STRUCTURAL ELEMENTS OF AIRCRAFT [VLIIANIE PEREGRUZOK NA RESURS ELEMENTOV AVIATSIONNYKH KONSTRUKTSII]
B. V. BOITSOV, IU. V. PETUKHOV, V. P. DUDKIN, and A. V. PLATONOV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 51-54. In Russian. refs
Copyright

A mathematical model is presented which allows for the effect of overloads on the growth of fatigue cracks in aircraft structures. The model is based on linear fracture mechanics and the hypothesis of fatigue crack closure. The model has been used to develop a computer program, written in FORTRAN, for calculating the time of fatigue crack growth. Calculations for steel 30KhGS are presented as an example. AIAA

A93-35290
SELECTION OF PROTECTIVE COATINGS FOR PARTS IN A COMPUTER-AIDED DESIGN SYSTEM [VYBOR ZASHCHITNOGO POKRYTIIA DETALI V AVTOMATIZIROVANNOI SISTEME KONSTRUIROVANIIA]
A. I. ZHELEZOV and N. M. KISELEV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 55-59. In Russian. refs
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The possibility of integrating the task of selecting protective coatings directly into the design process in a CAD system is discussed. The problem is formulated mathematically as an iteration problem, and a model is developed using the formalism of relational algebra. The model is implemented in application software for integration into a CAD system. AIAA

A93-35295
SELECTING A METHOD FOR SEALING RIVETED JOINTS IN FUEL COMPARTMENTS [VYBOR METODA GERMETIZATSII KLEPANYKH SHVOV V TOPLIVNYKH OTSEKAKH]
V. Z. KONDRASHOV *In* Ensuring the reliability and service life of flight vehicle structures by engineering methods Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 77-81. In Russian. refs
Copyright

The problem of obtaining sealed riveted joints while reducing the use of sealing compounds is discussed. In particular, attention is given to the method of increasing the radial interference during the installation of the rivets. It is shown that, in aluminum alloy structures, sealed joints can be obtained by producing residual compressive stresses that are a factor of 1.8-2 higher than those typically present in conventional riveted joints. Several different geometries of sealed riveted joints for fuel compartments are examined. AIAA

A93-35345
DYNAMICS OF THE BEHAVIOR OF NEMATIC FILMS IN GASDYNAMIC FLOWS [DINAMIKA POVEDENIIA NEMATICHESKIKH PLENOK V GAZODINAMICHESKIKH POTOKAKH]
G. M. ZHARKOVA, N. G. PREOBRAZHENSKII, and S. I. TRASHKEEV PMTF - Prikladnaia Mekhanika i Tekhnicheskaia Fizika (ISSN 0044-4626) no. 6 Nov.-Dec. 1992 p. 64-67. In Russian. refs
Copyright

In aerodynamic experiments, liquid crystals deposited in the form of a thin layer on the surface of a model may change their properties under the effect of temperature and mechanical shear. Here, flow-induced changes in the optical properties of nematic liquid crystals are analyzed for the case where the flow leads to a shear in a thin layer of a liquid crystal whose molecules are initially oriented in a certain manner. It is found, in particular, that slight changes in the flow rate may produce a substantial phase progression, which can be used to determine the surface friction. AIAA

A93-35492 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
REACTION ZONE STRUCTURE FOR STRONG, WEAK OVERDRIVEN, AND WEAK UNDERDRIVEN OBLIQUE DETONATIONS
JOSEPH M. POWERS and KEITH A. GONTHIER (Notre Dame Univ., IN; NASA, Lewis Research Center, Cleveland, OH) Physics of Fluids A (ISSN 0899-8213) vol. 4, no. 9 Sept. 1992 p. 2082-2089. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992 Research sponsored by NASA refs
Copyright

A simple dynamic systems analysis is used to give examples of strong, weak overdriven, and weak underdriven oblique detonations. Steady oblique detonations consisting of a straight lead shock attached to a solid wedge followed by a resolved reaction zone structure are admitted as solutions to the reactive Euler equations. This is demonstrated for a fluid that is taken to be an inviscid, calorically perfect ideal gas that undergoes a two-step irreversible reaction with the first step exothermic and the second step endothermic. This model admits solutions for a continuum of shock wave angles for two classes of solutions identified by a Rankine-Hugoniot analysis: strong and weak overdriven waves. The other class, weak underdriven, is admitted for eigenvalue shock-wave angles. Chapman-Jouguet waves, however, are not admitted. These results contrast those for a corresponding onestep model that, for detonations with a straight lead shock, only admits strong, weak overdriven, and Chapman-Jouguet solutions. Author

N93-24759*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A THREE-DIMENSIONAL ALGEBRAIC GRID GENERATION SCHEME FOR GAS TURBINE COMBUSTORS WITH INCLINED SLOTS Final Report
S. L. YANG, M. C. CLINE (Los Alamos National Lab., NM.), R. CHEN, and Y. L. CHANG Mar. 1993 25 p
(Contract NAG3-1109; RTOP 537-02-20)
(NASA-CR-191095; E-7674; NAS 1.26:191095) Avail: CASI HC A03/MF A01

A 3D algebraic grid generation scheme is presented for

generating the grid points inside gas turbine combustors with inclined slots. The scheme is based on the 2D transfinite interpolation method. Since the scheme is a 2D approach, it is very efficient and can easily be extended to gas turbine combustors with either dilution hole or slot configurations. To demonstrate the feasibility and the usefulness of the technique, a numerical study of the quick-quench/lean-combustion (QQ/LC) zones of a staged turbine combustor is given. Preliminary results illustrate some of the major features of the flow and temperature fields in the QQ/LC zones. Formation of co- and counter-rotating bulk flow and shape temperature fields can be observed clearly, and the resulting patterns are consistent with experimental observations typical of the confined slanted jet-in-cross flow. Numerical solutions show the method to be an efficient and reliable tool for generating computational grids for analyzing gas turbine combustors with slanted slots. Author

N93-24900# Lightning Location and Protection, Inc., Tucson, AZ.

A SINGLE-POINT WARNING SYSTEM FOR THUNDERSTORMS AND ELECTRIC FIELDS

W. T. NEUMANN, K. L. CUMMINS, and E. PHILIP KRIDER (Arizona Univ., Tucson.) *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 8 p Nov. 1992

Avail: CASI HC A02/MF A03

In this paper, we describe a single-point warning system that combines a single-station thunderstorm warning sensor with a static electric field sensor. This integrated system monitors nearby cloud-to-ground lightning and overhead electrification, allowing a wide variety of potentially hazardous meteorological conditions to be monitored. The paper discusses relevant sensing technologies, public safety and aviation applications for the system, recent field experience, and future development options. Author

N93-24903# United Kingdom Atomic Energy Authority, Abingdon (England). Lightning Test and Technology.

ALTERNATIVE EQUIPMENT TEST PROCEDURES FOR SIMULTANEOUS CURRENT INJECTION ON MULTIPLE CABLE BUNDLES

C. JOHN HARDWICK, STEPHEN J. HAIGH, and R. E. BALDWIN *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 9 p Nov. 1992 Sponsored by British Aerospace Aircraft Group; Civil Aviation Authority; Construcciones Aeronauticas S. A.; Dept. of Trade and Industry; Rolls-Royce Ltd.; Saab-Scania; and Short Bros. and Harland Ltd.

Avail: CASI HC A02/MF A03

Simple equipment tests can be accomplished by injecting currents into interconnect cables and adjusting the voltage injected into the loop under test or current in the cable until the ETDL is reached. However, for more complicated systems with several cables, this simple procedure is inadequate. This paper compares measurements made on cable bundles in a fuselage with both injection into the fuselage and injection on bundles to illustrate the problem and proposes alternative test methods. Author

N93-24963# Clarkson Univ., Potsdam, NY. Dept. of Chemical Engineering.

AN ANALYSIS OF LIFT FORCES ON AEROSOLS IN A WALL BOUNDED TURBULENT SHEAR FLOW

P. CHERUKAT and J. B. MCLAUGHLIN 1992 10 p Presented at the 13th Symposium on Turbulence, Rolla, MO, 22 Sep. 1992 (Contract DE-FG02-88ER-13919)

(DE93-003362; CONF-9209273-1) Avail: CASI HC A02/MF A01

This paper describes work that is expected to lead to a better understanding of the role of lift forces in the deposition of aerosols on the walls bounding a turbulent shear flow. After providing some background information about aerosol trajectories that was obtained from computer simulations, new results for the lift force in the relevant parameter ranges are presented. DOE

N93-25087*# Vigyan Research Associates, Inc., Hampton, VA.

A FEASIBILITY STUDY OF USING LANGLEY 0.3-M TRANSONIC CRYOGENIC TUNNEL SIDEWALL BOUNDARY-LAYER REMOVAL SYSTEM FOR HEAVY GAS TESTING Final Report

A. V. MURTHY, S. BALAKRISHNA, and W. ALLEN KILGORE Mar. 1993 25 p

(Contract NAS1-18585; RTOP 505-59-86-02)

(NASA-CR-191438; NAS 1.26:191438) Avail: CASI HC A03/MF A01

This report presents the results of a preliminary study for using the 0.3-m Transonic Cryogenic Tunnel sidewall boundary-layer removal system with heavy gas sulfur hexafluoride as the test medium. It is shown that the drive motor speed/power of the existing system and the additional heat load on the tunnel heat exchanger are the major problems limiting the boundary-layer removal system performance. Overcoming these problems can provide the capability to remove about 1.5 percent of the test section mass flow at Mach number M = 0.8 and about 5 percent at M = 0.25. Previous studies have shown that these boundary-layer mass flow removal rates can reduce the boundary-layer thickness by a factor of two at the model station. Also the effect of upstream boundary-layer removal on the airfoil test data is not likely to be significant under high lifting conditions. Near design conditions, corrections to the test Mach number may be necessary to account for sidewall boundary-layer effects. Author (revised)

N93-25109*# Duke Univ., Durham, NC. Dept. of Mechanical Engineering and Materials Science.

PREDICTION OF UNSTEADY FLOWS IN TURBOMACHINERY USING THE LINEARIZED EULER EQUATIONS ON DEFORMING GRIDS Final Technical Report

WILLIAM S. CLARK and KENNETH C. HALL Apr. 1993 110 p

(Contract NAG3-1192)

(NASA-CR-192919; NAS 1.26:192919) Avail: CASI HC A06/MF A02

A linearized Euler solver for calculating unsteady flows in turbomachinery blade rows due to both incident gusts and blade motion is presented. The model accounts for blade loading, blade geometry, shock motion, and wake motion. Assuming that the unsteadiness in the flow is small relative to the nonlinear mean solution, the unsteady Euler equations can be linearized about the mean flow. This yields a set of linear variable coefficient equations that describe the small amplitude harmonic motion of the fluid. These linear equations are then discretized on a computational grid and solved using standard numerical techniques. For transonic flows, however, one must use a linear discretization which is a conservative linearization of the nonlinear discretized Euler equations to ensure that shock impulse loads are accurately captured. Other important features of this analysis include a continuously deforming grid which eliminates extrapolation errors and hence, increases accuracy, and a new numerically exact, nonreflecting far-field boundary condition treatment based on an eigenanalysis of the discretized equations. Computational results are presented which demonstrate the computational accuracy and efficiency of the method and demonstrate the effectiveness of the deforming grid, far-field nonreflecting boundary conditions, and shock capturing techniques. A comparison of the present unsteady flow predictions to other numerical, semi-analytical, and experimental methods shows excellent agreement. In addition, the linearized Euler method presented requires one to two orders-of-magnitude less computational time than traditional time-marching techniques making the present method a viable design tool for aeroelastic analyses. Author (revised)

N93-25176*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMBINED LAURA-UPS HYPERSONIC SOLUTION PROCEDURE

WILLIAM A. WOOD and RICHARD A. THOMPSON Mar. 1993 24 p

(Contract RTOP 506-40-91-01)
(NASA-TM-107682; NAS 1.15:107682) Avail: CASI HC A03/MF A01

A combined solution procedure for hypersonic flowfields around blunted slender bodies was implemented using a thin-layer Navier-Stokes code (LAURA) in the nose region and a parabolized Navier-Stokes code (UPS) on the after body region. Perfect gas, equilibrium air, and non-equilibrium air solutions to sharp cones and a sharp wedge were obtained using UPS alone as a preliminary step. Surface heating rates are presented for two slender bodies with blunted noses, having used LAURA to provide a starting solution to UPS downstream of the sonic line. These are an 8 deg sphere-cone in Mach 5, perfect gas, laminar flow at 0 and 4 deg angles of attack and the Reentry F body at Mach 20, 80,000 ft equilibrium gas conditions for 0 and 0.14 deg angles of attack. The results indicate that this procedure is a timely and accurate method for obtaining aerothermodynamic predictions on slender hypersonic vehicles. Author (revised)

N93-25208*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
FLOW VISUALIZATIONS OF PERPENDICULAR BLADE VORTEX INTERACTIONS Semiannual Progress Report
MICHAEL C. RIFE and WILLIAM J. DAVENPORT 15 Oct. 1992 94 p
(Contract NAG1-1119)
(NASA-CR-192725; NAS 1.26:192725) Avail: CASI HC A05/MF A01

Helium bubble flow visualizations have been performed to study perpendicular interaction of a turbulent trailing vortex and a rectangular wing in the Virginia Tech Stability Tunnel. Many combinations of vortex strength, vortex-blade separation (Z(sub s)) and blade angle of attack were studied. Photographs of representative cases are presented. A range of phenomena were observed. For Z(sub s) greater than a few percent chord the vortex is deflected as it passes the blade under the influence of the local streamline curvature and its image in the blade. Initially the interaction appears to have no influence on the core. Downstream, however, the vortex core begins to diffuse and grow, presumably as a consequence of its interaction with the blade wake. The magnitude of these effects increases with reduction in Z(sub s). For Z(sub s) near zero the form of the interaction changes and becomes dependent on the vortex strength. For lower strengths the vortex appears to split into two filaments on the leading edge of the blade, one passing on the pressure and one passing on the suction side. At higher strengths the vortex bursts in the vicinity of the leading edge. In either case the core of its remnants then rapidly diffuse with distance downstream. Increase in Reynolds number did not qualitatively affect the flow apart from decreasing the amplitude of the small low-frequency wandering motions of the vortex. Changes in wing tip geometry and boundary layer trip had very little effect. Author

N93-25210# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
THE ATC EVALUATION OF THE PROTOTYPE AIRPORT SURVEILLANCE RADAR WIND SHEAR PROCESSOR (ASR-WSP) AT ORLANDO INTERNATIONAL AIRPORT Final Report
RADAME MARTINEZ Mar. 1993 21 p
(DOT/FAA/CT-TN92/48) Avail: CASI HC A03/MF A01

The Airport Surveillance Radar Wind Shear Processor (ASR-WSP), also known as Airport Surveillance Radar-9 (ASR-9) modification for low altitude wind shear detection, is a production ASR-9 with an expanded weather channel for added processing capabilities. The primary mission of the ASR-WSP is to enhance the safety of air travel through the timely detection and reporting of hazardous wind shear in and near the terminal approach and departure zones of the airport. It will also improve the management of air traffic (AT) in the terminal area through the forecast of precipitation, and ultimately the detection of other hazardous weather phenomena. The ASR-WSP may be used as a stand-alone system at airports without a Terminal Doppler Weather Radar (TDWR) or Enhanced-Low Level Wind Shear Alert System (E-LLWAS), or in an integrated mode with either or both the TDWR and E-LLWAS. An operational evaluation of a prototype ASR-WSP, developed by Massachusetts Institute of Technology Lincoln Laboratories (MIT/LL), was conducted at the Orlando International Airport (MCO) in Orlando, Florida, during the period 29 Jun. to 31 Aug. 1992. The objective of the evaluation was to obtain Federal Aviation Administration (FAA) air traffic controller reaction to the prototype ASR-WSP weather data and display equipment. The following are highlights of the evaluation: (1) the ASW-WSP is very useful when making runway configuration changes; (2) the ASR-WSP is not perceived to be as accurate as the prototype TDWR; (3) the gust front prediction feature is not reliable; and (4) the information provided on both the RDT and the GSD is very useful. Author (revised)

N93-25237 Dayton Univ., OH.
AN INVESTIGATION OF LASER VELOCIMETRY MEASUREMENTS WITHIN HIGH SPEED, COMPLEX FLOWS Ph.D. Thesis
MARK S. MAURICE 1992 212 p
Avail: Univ. Microfilms Order No. DA9239537

Laser velocimetry (LV) is a nonintrusive, optical method that measures particle velocities within a flow. Therefore, if LV measurements are to represent the structure of a flowfield, the particles must follow the dynamic motion of the fluid. However, in high speed, complex flows, the lag in particle response to fluid gradients can be substantial. In order to quantify velocity lag bias in high speed, mean velocity measurements, several flowfields are investigated experimentally and computationally. From measurements within the vortical flowfield of a supersonic delta wing at Mach 1.9, and for expansion flows at Mach 5.76, it is found that by coupling a particle equation of motion with the computational flowfield solutions, particle trajectories and velocity lag within complex flows can be predicted. For two primary flow structures, potential vortices and two-dimensional ideal shocks, it is found that relaxation distances can be quantified in terms of three dimensionless parameters. Results for these cases are presented graphically as an aid for test design and data analysis over a wide range of conditions. However, any analysis of velocity lag bias requires knowledge of the particle size distribution, which is often unknown in high speed flows. For a ten degree half-angle wedge at Mach Three, a methodology is presented which determines the mean particle diameter from measurements downstream of the shock, and then examines the remaining LV data throughout the flow. To extend this approach to flows with highly polydispersed particle sizes, an algorithm is developed which extracts the size distribution from the shape of LV velocity histograms. This method is applied to the investigation of a hypersonic inlet at Mach 5.76. Results show that despite the problem of velocity lag, measurements can still be used for computational code validation. In this final case, the developing boundary layer along the inlet ramp is accurately predicted, but the algebraic eddy viscosity model overestimates the turbulence production at the shock wave - boundary layer interactions.
Dissert. Abstr.

N93-25259 Stanford Univ., CA.
DIRECT SOLUTIONS OF THE NAVIER-STOKES EQUATIONS WITH APPLICATION TO STATIC AEROELASTICITY Ph.D. Thesis
FORT FRASER FELKER 1992 146 p
Avail: Univ. Microfilms Order No. DA9234093

A method was developed to directly calculate solutions to the steady, compressible, Navier-Stokes equations. Direct solutions do not involve an advance in time of an unsteady analysis, and neither time nor any 'time-like' variable appears in the system. The steady Navier-Stokes equations were discretized in space, and the resulting nonlinear system of algebraic equations was solved using Newton's method. The method exhibits rapid convergence, with the residual reduced to machine zero in approximately ten iterations. One of the benefits of this solution method is that it is straightforward to include the effects of other physical phenomena

on the fluid dynamics, and the effects of the fluid dynamics on the other phenomena. As an illustration of this, the direct solution method was extended to calculate the steady flow about a flexible body. The shape of the body depends on the fluid flow, and the fluid flow depends upon the shape of the body. There is no iteration between separate fluid dynamics and structures analyses. Rather, the solution for the complete aeroelastic system is found using the direct solution technique. The techniques used in the direct solution method, and the fluid/structure coupling are described. Important issues which arose during the implementation of the method, and their resolution, are reviewed. Sample calculations are presented for several two-dimensional, transonic, convergent-divergent nozzles, both with rigid and flexible walls. These calculations serve to illustrate the accuracy and efficiency of the direct solution method. Recommendations are provided for the directions of future research in this area. Dissert. Abstr.

N93-25266*# Pennsylvania State Univ., University Park. Gas Dynamics Lab.
AN EXPERIMENTAL STUDY OF THE SOURCES OF FLUCTUATING PRESSURE LOADS BENEATH SWEPT SHOCK/BOUNDARY-LAYER INTERACTIONS Final Technical Report, 1 Jan. 1990 - 31 Dec. 1992
G. S. SETTLES and S. GARG Apr. 1993 34 p
(Contract NAG1-1070)
(NASA-CR-192918; NAS 1.26:192918; PSGDL-R-92/93-0002)
Avail: CASI HC A03/MF A01

An experimental research program providing basic knowledge and establishing a database on the fluctuating pressure loads produced on aerodynamic surfaces beneath three dimensional shock wave/boundary layer interactions is described. Such loads constitute a fundamental problem of critical concern to future supersonic and hypersonic flight vehicles. A turbulent boundary layer on a flat plate is subjected to interactions with swept planar shock waves generated by sharp fins at angle of attack. Fin angles from 10 to 20 deg at freestream Mach numbers of 3 and 4 produce a variety of interaction strengths from weak to very strong. Miniature Kulite pressure transducers flush-mounted in the flat plate are used to measure interaction-induced wall pressure fluctuations. The distributions of properties of the pressure fluctuations, such as their ring levels, amplitude distributions, and power spectra, are also determined. Measurements were made for the first time in the aft regions of these interactions, revealing fluctuating pressure levels as high as 160 dB. These fluctuations are dominated by low frequency (0-5 kHz) signals. The maximum ring levels in the interactions show an increasing trend with increasing interaction strength. On the other hand, the maximum ring levels in the forward portion of the interactions decrease linearly with increasing interaction sweep back. These ring pressure distributions and spectra are correlated with the features of the interaction flowfield. The unsteadiness of the off-surface flowfield is studied using a new, non-intrusive technique based on the shadow graph method. The results indicate that the entire lambda-shock structure generated by the interaction undergoes relatively low-frequency oscillations. Some regions where particularly strong fluctuations are generated were identified. Fluctuating pressure measurements are also made along the line of symmetry of an axisymmetric jet impinging upon a flat plate at an angle. This flow was chosen as a simple analog to the impinging jet region found in the rear portion of the shock wave/boundary layer interactions under study. It is found that a sharp peak in ring pressure level exists at or near the mean stagnation point. It is suggested that the phenomena responsible for this peak may be active in the swept interactions as well, and may cause the extremely high fluctuating pressures observed in the impinging jet region in the present experimental program. Author (revised)

N93-25427# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA: ENGINEERING AND EQUIPMENT
12 Mar. 1992 32 p Transl. into ENGLISH from various Russian articles
(JPRS-UEQ-92-003) Avail: CASI HC A03/MF A01

Translated articles cover the following topics: oscillation stability of simple pendulum on moving frame at upper and lower trajectory points; and calculating gas turbine engine parts' coefficient of strengthening by balls in ultrasonic field. CASI

N93-25518# Iowa State Univ. of Science and Technology, Ames. Center for Aviation Systems Reliability.
INVESTIGATION OF CORROSION IN ALUMINUM/ADHESIVE LAP-SPLICES USING PULSE-ECHO ULTRASONIC TECHNIQUES
T. C. PATTON and D. K. HSU 1992 8 p Presented at the Review of Progress in Quantitative Non Destructive Evaluation, La Jolla, CA, 19-24 Jul. 1992
(Contract W-7405-ENG-82)
(DE93-008074; IS-M-740; CONF-920799-5) Avail: CASI HC A02/MF A01

In this paper we have shown that aluminum skin samples corroded in the laboratory by an electrochemical process are similar to corrosion that occurs naturally. Incorporating the corroded skins into several sets of characterized aluminum/adhesive lap-splices with first and second layer corrosion defects, we have shown qualitative agreement in PP signal amplitude between a low frequency ultrasonic model and experiment. The model suggests, and the experimental evidence agrees, that the trailing signal PP amplitude of a low frequency tri-polar pulse can be used to discriminate metal thinning in the second layer due to corrosion. Further work is in progress to address the issues of frequency selection and errors caused by layer parameter approximation. DOE

N93-25540 Rice Univ., Houston, TX.
NUMERICAL STUDY OF CAVITY NATURAL CONVECTION FLOW WITH AUGMENTING AND COUNTERACTING EFFECTS BY PROJECTION FINITE ELEMENT METHOD Ph.D. Thesis
TSWEN-CHYUAN JUE 1992 182 p
Avail: Univ. Microfilms Order No. DA9234421

A numerical study of natural convection in cavities under the effects of thermocapillarity and gravity modulation is conducted in this research. Three different algorithms which are first-order explicit, second-order Taylor-Galerkin and semi-implicit schemes based on the projection finite element method (FEM) are developed. Each algorithm presents its own characteristics and advantages. By considering the problem characteristics and computational efficiency, the semi-implicit method is a better choice for this research. In this thesis, the physical investgation of cavity natural convection with augmenting or counteracting effects is divided into four parts. At first, the cavity flow with buoyancy force and thermocapillary effect is studied for different Marangoni numbers and aspects ratios. Next, the Benard convection with gravity modulation effects in normal gravity and zero-g gravity is investigated. The natural convection flow exhibits dramatically different flow structure under the influence of different modulation directions and frequencies. In addition, the natural convection with combined thermocapillarity and gravity modulation is explored for different modulation directions, frequencies and Marangoni numbers. Finally, the cavity natural convection flow with a deformable free surface is analyzed for different Grashof numbers and Marangoni numbers. Results of this research show that the surface tension provides a strong influence in the natural convection flow in both normal gravity and microgravity states. Particularly, the low aspect ratio and microgravity environments favor the development of thermocapillary-driven flow. On the other hand, the existence of gravity modulation makes the flow field different from the constant gravity state by applying different modulation directions and frequencies. The simultaneous presence of thermocapillarity and g-jitter creates a dramatically different flow pattern when compared to the results without thermocapillary effect. When a deformable free surface is considered, the flow field and heat transfer rate at the corners of free surface are changed due to the deformation of free surface shape. Dissert. Abstr.

N93-25579*# Extrude Hone Corp., Irwin, PA.
ON MACHINE CAPACITANCE DIMENSIONAL AND SURFACE PROFILE MEASUREMENT SYSTEM
RALPH RESNICK *In* NASA, Washington, Technology 2002: The Third National Technology Transfer Conference and Exposition, Volume 1 p 178-181 Feb. 1993
Avail: CASI HC A01/MF A04

A program was awarded under the Air Force Machine Tool Sensor Improvements Program Research and Development Announcement to develop and demonstrate the use of a Capacitance Sensor System including Capacitive Non-Contact Analog Probe and a Capacitive Array Dimensional Measurement System to check the dimensions of complex shapes and contours on a machine tool or in an automated inspection cell. The manufacturing of complex shapes and contours and the subsequent verification of those manufactured shapes is fundamental and widespread throughout industry. The critical profile of a gear tooth; the overall shape of a graphite EDM electrode; the contour of a turbine blade in a jet engine; and countless other components in varied applications possess complex shapes that require detailed and complex inspection procedures. Current inspection methods for complex shapes and contours are expensive, time-consuming, and labor intensive. Author

N93-25580*# Extrude Hone Corp., Irwin, PA.
ULTRASONIC POLISHING
RANDY GILMORE *In* NASA, Washington, Technology 2002: The Third National Technology Transfer Conference and Exposition, Volume 1 p 182-192 Feb. 1993
Avail: CASI HC A03/MF A04

The ultrasonic polishing process makes use of the high-frequency (ultrasonic) vibrations of an abradable tool which automatically conforms to the work piece and an abrasive slurry to finish surfaces and edges on complex, highly detailed, close tolerance cavities in materials from beryllium copper to carbide. Applications range from critical deburring of guidance system components to removing EDM recast layers from aircraft engine components to polishing molds for forming carbide cutting tool inserts or injection molding plastics. A variety of materials including tool steels, carbides, and even ceramics can be successfully processed. Since the abradable tool automatically conforms to the work piece geometry, the ultrasonic finishing method described offers a number of important benefits in finishing components with complex geometries. Author (revised)

N93-25599*# Colorado Univ., Boulder. Dept. of Electrical and Computer Engineering.
VARIABLE-SPEED GENERATORS WITH FLUX WEAKENING
A. A. FARDOUN, E. F. FUCHS, and P. W. CARLIN (Midwest Research Inst., Golden, CO.) *In* NASA, Washington, Technology 2002: The Third National Technology Transfer Conference and Exposition, Volume 1 p 353-362 Feb. 1993
Avail: CASI HC A02/MF A04

A cost-competitive, permanent-magnet 20 kW generator is designed such that the following criteria are satisfied: an (over) load capability of at least 30 kW over the entire speed range of 60-120 rpm, generator weight of about 550 lbs with a maximum radial stator flux density of 0.82 T at low speed, unity power factor operation, acceptably small synchronous reactances and operation without a gear box. To justify this final design four different generator designs are investigated: the first two designs are studied to obtain a speed range from 20 to 200 rpm employing rotor field weakening, and the latter two are investigated to obtain a maximum speed range of 40 to 160 rpm based on field weakening via the stator excitation. The generator reactances and induced voltages are computed using finite element/difference solutions. Generator losses and efficiencies are presented for all four designs at rated temperature of Tr=120C. Author

N93-25705 Pennsylvania State Univ., University Park.
HEAT TRANSFER MEASUREMENTS IN SWEPT SHOCK WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS Ph.D. Thesis
YEOL LEE 1992 187 p
Avail: Univ. Microfilms Order No. DA9236860

An experimental research program providing basic knowledge and establishing a database on the heat transfer in three-dimensional shock wave/boundary-layer interaction is described. High thermal loading in such interactions constitutes a fundamental problem of critical concern to future supersonic and hypersonic flight vehicles. A turbulent boundary-layer on a flat plate is subjected to interactions with swept planar shock waves generated by a sharp fin. Fin angles from 10 deg to 20 deg at freestream Mach numbers 3.0 and 4.0 produce a variety of interaction strengths from weak to very strong. A foil heater generates a uniform heat flux over the surface of interest and thin-film resistance thermometers mounted on it are used to measure the local surface temperature. The heat convection equation is then used to calculate the local heat transfer coefficients. The present heat transfer technique is applied to measure heat transfer distributions for 5 different interaction cases. The experimental data are compared with numerical Navier-Stokes solutions. The estimation of total uncertainty of the present measurements is about plus or minus 10 percent, which makes them suitable for CFD code validation purposes. The measured peak heat transfer data are correlated with the normal Mach number based on the concept of the quasi-conical nature of such interactions, and the results show good agreement with other experimental data. Dissert. Abstr.

N93-25737 Missouri Univ., Rolla.
TWO-DIMENSIONAL FIN ANALYSIS Ph.D. Thesis
HYUNG SUK KANG 1992 110 p
Avail: Univ. Microfilms Order No. DA9224672

This dissertation deals with the variation of heat loss from the fin and the temperature distribution within the fin using a two-dimensional analysis for rectangular and triangular fins. For the rectangular fins, the root temperature is assumed to vary as cosine function across the fin root and the surface convection coefficients of the fin are assumed to be constant but unequal. The analysis is restricted to Biot numbers (= hl/k) such that 0 is less than or equal to B2 is less than or equal to B1 is less than or equal to 1, and B1 = 1, 0.1, 0.01, where B1 is the Biot number of the top surface and B2 is the Biot number of the bottom surface. For the triangular fins, the root temperature and surface convection coefficient are assumed to be constant. A comparison of the two dimensional temperature distribution within the fin and heat transfer rate from the fine, computed using a non-traditional (forced) analytic method and finite difference method, is made. Finally a one-dimensional analyses of the triangular fin is made using a statistical method. The results of these analyses will be helpful when the actual experimental set up is built and used in the laboratory. For the rectangular fins, the results show that the value of the tip Biot number is not important in the heat loss predictions when B1 and B2 are large. Under certain circumstances, the heat loss from the fin is essentially independent of the ratio of the fin length to the fin half width. For the triangular fins, the results show that when the Biot number is less than 0.1 (i.e., under usual circumstances), the forced analytic method is applicable. The statistical method yields a reasonably accurate value of the convection coefficient, h, using actual experimental data. Dissert. Abstr.

N93-25753 Maryland Univ., College Park.
LARGE-EDDY SIMULATION OF TEMPORALLY DEVELOPING BOUNDARY LAYERS WITH EMBEDDED STREAMWISE VORTICES Ph.D. Thesis
HOSSEIN ESMAILI 1992 147 p
Avail: Univ. Microfilms Order No. DA9234560

The interaction of streamwise vortices with turbulent boundary layer has been investigated using large-eddy simulation. The embedded vortices are a pair of counter-rotating Oseen vortices with flow between them directed towards the wall (common-flow-down), superimposed on various instantaneous realizations of flat plate and sink flow turbulent boundary layers.

The time development of the vortices and their interaction with the boundary layer are studied by integrating the filtered Navier-Stokes equations in time. The most important effects of the vortices on the boundary layer are the thinning of the boundary layer in the downwash region between the vortices and its thickening in the upwash region. The Reynolds stress profiles highlight the highly three-dimensional structure of the turbulent boundary layer modified by the vortices. The presence of significant turbulent activity near the vortex center and in the upwash region where inflectional velocity profiles are observed, suggests that localized instability mechanisms in addition to the convection of turbulent energy by the secondary flow are responsible for this effect. High levels of secondary stresses in the vicinity of the vortex center are also observed. These simulations also indicate that eddy viscosity models should be expected to perform poorly in the vortex core region. The numerical results for the flat plate turbulent boundary layer show good agreement with the experimental results of Pauley and Eaton (1988a,b). The mean features of flow show the same patterns for both the flat plate and sink flow turbulent boundary layers. Dissert. Abstr.

N93-25884*# Cincinnati Univ., OH.
COMPUTATIONAL GEARING MECHANICS Final Report
RONALD L. HUSTON Apr. 1993 11 p
(Contract NSG-3188; DA PROJ. 1L1-62211-A-47-A; RTOP 505-62-10)
(NASA-CR-191127; E-7808; NAS 1.26:191127; ARL-CR-43)
Avail: CASI HC A03/MF A01

This is an expository report summarizing the research efforts and results under NASA Grant NSG-3188 to the University of Cincinnati. Since the grant has now ended this report also serves as a final report for the grant. The focus of the research has been computational gearing mechanics. Research on gear geometry, gear stress, and gear dynamics is discussed. Current research and planned future efforts are also discussed. A comprehensive bibliography is presented. Author

N93-25912# Naval Postgraduate School, Monterey, CA.
EXPERIMENTAL STUDY OF THE EFFECT OF HELICAL GROOVES ON AN INFINITE CYLINDER M.S. Thesis
THOMAS D. SUART Dec. 1992 124 p
(AD-A260890) Avail: CASI HC A06/MF A02

A series of low-speed wind-tunnel investigations were conducted to determine the aerodynamic behavior of a grooved inclined cylinder representing a long trailing wire antenna towed from an orbiting airplane. The large angle-of-attack range of the trailing wire required two different model configurations. The first configuration, using full-scale wire lengths suspended between steel stanchions, was mounted on a flush four-degree-of-freedom wall balance. The second configuration used a 15-scale grooved cylinder model with an ogive nose mounted on a six-degree-of-freedom sting balance. Wall balance wire data, valid for higher angles of attack, were integrated with low angle-of-attack sting balance data. Empirical relationships for the normal and axial force coefficients were verified with historical references for tested clean circular cylinders and extended for the grooved configurations. Existence of a side force coefficient due to circulation caused by the helical grooves was discovered, expressed analytically, and verified with flow-visualization techniques. Finally, the experimental coefficients were used to improve an existing simulation model describing the static equilibrium conditions of a cable towed by an airplane in a circular orbit. Inclusion of the side force influence in the static model proved consistent with the lateral skew angle and direction observed during flight test. DTIC

N93-25951# North Carolina Agricultural and Technical State Univ., Greensboro. Dept. of Mechanical Engineering.
UNIFORM ROUGHNESS STUDIES Final Report, Sep. 1987 - Mar. 1992
D. E. KLETT and M. KITHCART May 1992 82 p
(Contract F33615-C-87-3022)
(WL-TR-92-3041) Avail: CASI HC A05/MF A01

Heat transfer, skin friction, turbulence intensity, and velocity profile data were obtained for 22 different rough surfaces in turbulent subsonic boundary layer air flow. The rough surfaces consisted of hemispherical dimples, hemispherical protrusions, and rectangular protrusions. The rectangular roughness plates were tested with the tops of the elements flush with the upstream smooth surface and with the tops protruding above the smooth surface. The surfaces with protrusions were designed to have values of the Simpson roughness shape/spacing parameter that bracket the peak in the equivalent sand-grain correlation. The data was used for comparison with predictions from a discrete element rough surface boundary layer code in an attempt to improve the code's performance for cases of closely spaced roughness elements when wakes behind individual elements overlap. An anomaly was discovered in the code that causes wide variations in predicted drag and heat transfer for small variations in element drag coefficient C(sub d). The problem lies in the effect of C(sub d) on the velocity calculation giving rise to inflections in the calculated velocity profile near the crests of the roughness elements. A remedy to the problem has not, as yet, been found. Author (revised)

N93-26000* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
METHOD OF MEASURING CROSS-FLOW VORTICES BY USE OF AN ARRAY OF HOT-FILM SENSORS Patent
AVAL K. AGARWAL, inventor (to NASA), DAL V. MADDALON, inventor (to NASA), and SIVA M. MANGALAM, inventor (to NASA) 11 May 1993 9 p Filed 7 Jan. 1992 Supersedes N92-30390 (30 - 21, p 3628)
(NASA-CASE-LAR-14824-1-SB; US-PATENT-5,209,111; US-PATENT-APPL-SN-823805; US-PATENT-CLASS-73-147; US-PATENT-CLASS-73-178R; US-PATENT-CLASS-73-204.11; INT-PATENT-CLASS-G01M-9/00) Avail: US Patent and Trademark Office

The invention is a method for measuring the wavelength of cross-flow vortices of air flow having streamlines of flow traveling across a swept airfoil. The method comprises providing a plurality of hot-film sensors. Each hot-film sensor provides a signal which can be processed, and each hot-film sensor is spaced in a straight-line array such that the distance between successive hot-film sensors is less than the wavelength of the cross-flow vortices being measured. The method further comprises determining the direction of travel of the streamlines across the airfoil and positioning the straight-line array of hot film sensors perpendicular to the direction of travel of the streamlines, such that each sensor has a spanwise location. The method further comprises processing the signals provided by the sensors to provide root-mean-square values for each signal, plotting each root-mean-square value as a function of its spanwise location, and determining the wavelength of the cross-flow vortices by noting the distance between two maxima or two minima of root-mean-square values.

Official Gazette of the U.S. Patent and Trademark Office

N93-26008* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WORKSHOP REPORT: A VALIDATION STUDY OF NAVIER-STOKES CODES FOR TRANSVERSE INJECTION INTO A MACH 2 FLOW
DEAN R. EKLUND (Analytical Services and Materials, Inc., Hampton, VA.), G. BURTON NORTHAM, J. C. MCDANIEL (Virginia Univ., Charlottesville.), and CLIFF SMITH (CFD Research Corp., Huntsville, AL.) *In* JHU, 29th JANNAF Combustion Subcommittee Meeting, Volume 2 p 19-34 Oct. 1992 Previously announced as A93-21330
Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

A CFD (Computational Fluid Dynamics) competition was held at the Third Scramjet Combustor Modeling Workshop to assess the current state-of-the-art in CFD codes for the analysis of scram jet combustors. Solutions from six three-dimensional Navier-Stokes codes were compared for the case of staged injection of air behind a step into a Mach 2 flow. This case was investigated experimentally

at the University of Virginia and extensive in-stream data was obtained. Code-to-code comparisons have been made with regard to both accuracy and efficiency. The turbulence models employed in the solutions are believed to be a major source of discrepancy between the six solutions. Author

N93-26160# Federal Aviation Administration, Atlantic City, NJ.
THE DATA MULTIPLEXING NETWORK (DMN) PHASE 3 EXTENDED DISTANCE DATA CABLE (EDDC) TEST AND EVALUATION
WAYNE E. BELL, PHILLIP P. HOANG, and EDWARD N. LIND May 1993 118 p
(DOT/FAA/CT-TN93/11) Avail: CASI HC A06/MF A02

This test report contains the results of the Extended Distance Data Cable (EDDC) Test and Evaluation of the Data Multiplexing Network (DMN) Phase 3B Commercial Off-The-Shelf (COTS) equipment. The test was accomplished at the Federal Aviation Administration (FAA) Technical Center. The test results determined the maximum cable length of low loss cable and octopus cable which can be installed with the DMN Phase 3B COTS equipment. Report ASM-300 will prepare the Network Engineering Drawing and Cable Management for the first Operational Readiness Demonstration (ORD) site, Minneapolis Air Route Traffic Control Center (ARTCC), based on the results of this test.
Author (revised)

N93-26167# Naval Postgraduate School, Monterey, CA.
MODEL FAN PASSAGE FLOW SIMULATION M.S. Thesis
DAVID D. MYRE Dec. 1992 172 p
(AD-A261613) Avail: CASI HC A08/MF A02

Two-dimensional experimental and numerical simulations of a transonic fan blade passage were conducted at a Mach number of 1.4 to provide baseline data for the study of the effects of vortex generating devices on the suction surface shock-boundary layer interaction. In the experimental program, a probe and traverse system were designed and constructed. A new data acquisition system was adapted to record data from probe measurements and multiple scans of static pressure ports. Impact pressure behind two model fan passages and static pressures across the shock-boundary layer interaction were measured for a design and one off-design flow incidence in a blow-down wind tunnel. The passage shocks were positioned in similar locations by rotating the model to a decreased flow incidence. Fan passage losses were obtained by integrating probe measurements. The losses compared favorably with a numerical Navier-Stokes solution and one engineering loss model, Static pressure distributions were also found to compare favorably with numerical results. DTIC

N93-26202*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FABRICATION OF COMPOSITE PROPFAN BLADES FOR A CRUISE MISSILE WIND TUNNEL MODEL
E. BRIAN FITE Apr. 1993 30 p
(Contract RTOP 535-03-10)
(NASA-TM-105270; E-7327; NAS 1.15:105270) Avail: CASI HC A03/MF A01

This report outlines the procedures that were employed in fabricating prototype graphite-epoxy composite prop fan blades. These blades were used in wind tunnel tests that investigated prop fan propulsion system interactions with a missile airframe in order to study the feasibility of an advanced-technology-propfan-propelled missile. Major phases of the blade fabrication presented include machining of the master blade, mold fabrication, ply cutting and assembly, blade curing, and quality assurance. Specifically, four separate designs were fabricated, 18 blades of each geometry, using the same fabrication technique for each design. Author

N93-26526# Boeing Defense and Space Group, Seattle, WA.
X-RAY COMPUTED TOMOGRAPHY FOR CASTING DEVELOPMENT Interim Report, May 1991 - Feb. 1992
GARY E. GEORGESON, ALAN R. CREWS, and RICHARD H. BOSSI 30 Sep. 1992 52 p
(Contract F33615-88-C-5404; AF PROJ. 3153)
(AD-A261786; WL-TR-92-4032) Avail: CASI HC A04/MF A01

Computed tomography (CT) has been used to evaluate specific sand casting product examples for technical and economic benefits. The representative results are applicable to other casting technologies as well. CT has been shown to be cost effective in the development of new castings. The areas which would benefit include internal dimensional measurements (eliminating destructive sectioning), specific region inspections, flaw characterization in critical regions (to allow passing or informed repair of castings), and geometric acquisition for CAD/CAM. The quantitative capability of CT allows an engineering evaluation of castings based upon a correlation with performance. This quantitative measurement capability has also been used to measure the benefit of hot isostatic pressing in casting production. CT is also cost effective for engineering design and analysis by providing rapid geometry acquisition for input to computer aided design systems. This is particularly beneficial for components that do not have existing drawings or cannot be adequately defined until they are made for any reason. Presently CT can serve as an engineering aid to casting manufacturing. In order for CT evaluation to become routine in foundry applications, however, casting designers need to call it out as a measurement technique in the original casting design drawings, specifications on the application of CT must be written, contracts must include CT evaluation as a means for accepting casting quality, and lower cost CT systems must be available.
DTIC

N93-26564# Engineered Designs, Inc., Cincinnati, OH.
ADVANCED BRISTLE SEALS FOR GAS TURBINE ENGINES Final Report, May - Nov. 1992
JERRY L. CABE 28 Jan. 1993 45 p
(Contract DAAJ02-92-C-0008)
(AD-A261296; FR9201-01) Avail: CASI HC A03/MF A01

A seven month proof-of-concept program was conducted for an advanced bristle seal, called a bush seal, for use in gas turbine engines. This program was performed as a Small Business Innovation Research (SBIR) Phase 1 project. Bush seal specimen and a full ring bush seal were designed, evaluated, and manufactured for testing. An analytical study of the potential of the bush seal relative to a labyrinth seal was conducted. Static and dynamic testing of the bush seal was performed to determine the behavior of the bristles under pressurization and during contact with a rotating labyrinth tooth. Stable behavior of the bristle elements was observed during static pressurization of a full ring bush seal. The dynamic testing of various configurations of bush seal against a rotating labyrinth tooth showed minimal wear of the bristles relative to a conventional labyrinth seal. The development and application of the bush seal concept to gas turbine engines has the potential of improving the engine's performance while decreasing the degradation of the seal performance over time. DTIC

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A93-33773
NOWCASTS OF THUNDERSTORM INITIATION AND EVOLUTION
JAMES W. WILSON and CYNTHIA K. MUELLER (NCAR, Boulder, CO) Weather and Forecasting (ISSN 0882-8156) vol. 8, no. 1 March 1993 p. 113-131. Research supported by NSF refs
(Contract DTFA01-90-Z-02049)

Experimental space-specific 30-min nowcasts of thunderstorm initiation, evolution, and movement are reported. The experiments were conducted near Denver, Colorado, in order to provide weather information for planning purposes to air traffic control managers. The nowcasts were based primarily on Doppler weather radar observations of the clear-air boundary layer, storm reflectivity, storm Doppler velocity structure, and visual observations of clouds. The forecasters found that they could often anticipate thunderstorm initiation by monitoring radar-detected boundary-layer convergence lines together with monitoring visual observations of cloud development in the vicinity of the convergence lines. The forecaster results were better than persistence or extrapolation forecasts because of the ability to nowcast storm initiation and dissipation. AIAA

A93-34694* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
AIRCRAFT MEASUREMENT OF ELECTRIC FIELD - SELF-CALIBRATION
W. P. WINN (New Mexico Inst. of Mining and Technology, Socorro) Journal of Geophysical Research (ISSN 0148-0227) vol. 98, no. D4 April 20, 1993 p. 7351-7365. Research supported by USAF and U.S. Navy refs
(Contract NAG8-751; NSF ATM-89-19697)
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Aircraft measurement of electric fields is difficult as the electrically conducting surface of the aircraft distorts the electric field. Calibration requires determining the relations between the undistorted electric field in the absence of the vehicle and the signals from electric field meters that sense the local distorted fields in their immediate vicinity. This paper describes a generalization of a calibration method which uses pitch and roll maneuvers. The technique determines both the calibration coefficients and the direction of the electric vector. The calibration of individual electric field meters and the elimination of the aircraft's self-charge are described. Linear combinations of field mill signals are examined and absolute calibration and error analysis are discussed. The calibration method was applied to data obtained during a flight near thunderstorms. AIAA

A93-35372
POTENTIAL IMPACT OF COMBINED NO(X) AND SO(X) EMISSIONS FROM FUTURE HIGH SPEED CIVIL TRANSPORT AIRCRAFT ON STRATOSPHERIC AEROSOLS AND OZONE
S. BEKKI and J. A. PYLE (Cambridge Univ., United Kingdom) Geophysical Research Letters (ISSN 0094-8276) vol. 20, no. 8 April 23, 1993 p. 723-726. Research supported by Department of Environment and Universities Global Atmospheric Modelling Programme of United Kingdom refs
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A 2D sulphate aerosol model is used to assess the impact of combined NO(x) and SO(x) emissions from future High Speed Civil Transports on stratospheric aerosols and ozone. The model predicts that SO(x) emitted by this fleet of supersonics may double the aerosol surface area and the number of optically active particles below 20 km in the northern lower stratosphere. When the heterogeneous conversion of N2O5 to HNO3 on sulphate aerosols is taken into account, the predicted ozone changes due to future HSCTs emissions are smaller than those calculated when SO(x) and the subsequent increase in aerosol loading are neglected. It is worth noting that the doubling of the aerosol surface area may lead not only to a reduction in predicted ozone sensitivity to NO(x), but also to an enhancement in ozone sensitivity to chlorine in the lower stratosphere. Author (revised)

A93-35689
STUDIES OF ATMOSPHERIC EDDY DYNAMICS AND ENERGETICS AND CLIMATE PROBLEMS [ISSLEDOVANIIA VIKHREVOI DINAMIKI I ENERGETIKI ATMOSFERY I PROBLEMA KLIMATA]
E. G. NIKIFOROV, ED. and V. F. ROMANOV, ED. (Arkticheskii i Antarkticheskii NII, St. Petersburg, Russia) Leningrad Gidrometeoizdat 1990 368 p. In Russian. No individual items are abstracted in this volume
(ISBN 5-286-00610-8) Copyright

The papers presented in this volume provide an overview of recent research related to the eddy dynamics and energetics of the atmosphere, as part of the theory of general atmospheric circulation and climate. Topics discussed include diagnostic studies of the synoptic eddy energetics of the atmosphere, a hydromechanical model of the motion of atmospheric eddies of synoptic scale, a numerical model of synoptic eddies in a baroclinic atmosphere, and thermodynamic relations for describing macroturbulent eddy transfer of heat, moisture, and momentum in climatic models. Attention is also given to the modeling of the long-period climate dynamics, response of the upper ocean layer and climate relaxation, and characteristics of energy exchange for zonal and meridional types of atmospheric circulation. AIAA

N93-24875# Federal Aviation Administration, Atlantic City, NJ.
THE 1992 INTERNATIONAL AEROSPACE AND GROUND CONFERENCE ON LIGHTNING AND STATIC ELECTRICITY: ADDENDUM
Nov. 1992 309 p Conference held in Atlantic City, NJ, 6-8 Oct. 1992 Sponsored in part by National Interagency Coordinating Group and Florida Inst. of Tech.
(DOT/FAA/CT-92/20-ADD-1) Avail: CASI HC A14/MF A03

This report supplements the compilation of papers presented at the 1992 International Aerospace and Ground Conference on Lightning and Static Electricity. It includes papers concerning lightning phenomenology, lightning characterization, modeling and simulation, test criteria and techniques, and protection of both airborne and ground systems.

N93-24883# Galaxy Scientific Corp., Pleasantville, NJ.
LIGHTNING DATA ACQUISITION
ROSEMARIE L. MCDOWALL, J. ANDERSON PLUMER (Lightning Technologies, Inc., Pittsfield, MA.), and MICHAEL S. GLYNN (Federal Aviation Administration, Atlanta, GA.) *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 7 p Nov. 1992
Avail: CASI HC A02/MF A03

Three data collection programs are being pursued to acquire data which may be useful in the Federal Aviation Administration (FAA) lightning databases. The Commercial Lightning Database (CLD) program solicits lightning strike data from commercial and general aviation pilots via a form filled out by the pilot when his aircraft is struck. Current airline participants are American and Delta. Another source of data is the Bureau of Land Management (BLM) which runs a network of lightning sensors covering the 11 western states of the United States. Data on approximately 13 million strikes between 1985 and 1990 have been reviewed. In addition to these two sources, the Organization of Flying Adjusters (OFA) and the Aircraft Owners and Pilots Association (AOPA) are starting to supply data from their files. Author

N93-24884# Electro Magnetic Applications, Inc., Denver, CO.
DIGITIZATION OF ANALOG DATA FROM IN-FLIGHT LIGHTNING STRIKES
JAMES R. ELLIOTT and HENRY S. WEIGEL *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 10 p Nov. 1992
(Contract DTFA03-86-C-60027; DTFA03-86-C-00042)
Avail: CASI HC A02/MF A03

Analog recorded data from in flight lightning strikes has been converted for installation in the FAA Research and Development Electromagnetic Database (FRED). One second of data associated with a lightning event is digitized for each of an ensemble of electromagnetic sensors. The digitization and conversion process, which yields as many as 4 million samples for a sensor, is described. Author

N93-24895# Lightning Technologies, Inc., Pittsfield, MA.
LIGHTNING PHENOMENOLOGY BASES FOR FULL THREAT RETURN STROKE OCCURRENCE FOLLOWING EXTENDED LEADER SWEEP AT FLIGHT ALTITUDES
J. ANDERSON PLUMER *In* FAA, The 1992 International Aerospace and Ground Conference on Lightning and Static Electricity: Addendum 18 p Nov. 1992
Avail: CASI HC A03/MF A03

It has been recognized that lightning leaders sweep aft from initial attachment points on aircraft forward extremities prior to arrival of the first return stroke, which, in a cloud-to-earth flash, is not initiated until a branch of the leader reaches the earth. This process has lead to more realistic procedures for locating lightning strike Zone 1A on aircraft surfaces, with the result that Zone 1A covers considerably more of the aircraft surfaces than previous zone location methods (i.e., 'the 18-inch criteria') would indicate. Some observers have suggested that, whereas the leader may indeed sweep a considerable distance alongside fast moving aircraft at flight altitudes, the intensity of the ensuing first return stroke will be less than it would be at the ground terminus of the lightning channel, because a portion of leader charge is below, not above, the airplane. Analytical models of lightning channels are often cited to support this, since such models often show reduction of the stroke intensity (i.e., peak current and action integral) with distance from the earth terminus. Physical damage on aircraft struck in flight belies this contention, however, as damage indicative of severe return strokes is often seen well beyond 18 inches aft of initial leader attachments. This paper discusses the natural lightning characteristics that explain why severe first return strokes may arrive well aft of forward extremity tips of aircraft, and why zone location methods must account for this. It is the third paper in a series begun in 1980 by the author on the topic of swept leader and zone location methodology, and presented at these conferences. Author

N93-24975# Pacific Northwest Lab., Richland, WA.
AN EVALUATION OF THERMAL ENERGY STORAGE OPTIONS FOR PRECOOLING GAS TURBINE INLET AIR
Z. I. ANTONIAK, D. R. BROWN, and M. K. DROST Dec. 1992 32 p
(Contract DE-AC06-76RL-01830)
(DE93-005980; PNL-8427) Avail: CASI HC A03/MF A01

Several approaches have been used to reduce the temperature of gas turbine inlet air. One of the most successful uses off-peak electric power to drive vapor-compression-cycle ice makers. The ice is stored until the next time high ambient temperature is encountered, when the ice is used in a heat exchanger to cool the gas turbine inlet air. An alternative concept would use seasonal thermal energy storage to store winter chill for inlet air cooling. The objective of this study was to compare the performance and economics of seasonal thermal energy storage in aquifers with diurnal ice thermal energy storage for gas turbine inlet air cooling. The investigation consisted of developing computer codes to model the performance of a gas turbine, energy storage system, heat exchangers, and ancillary equipment. The performance models were combined with cost models to calculate unit capital costs and levelized energy costs for each concept. The levelized energy cost was calculated for three technologies in two locations (Minneapolis, Minnesota and Birmingham, Alabama). Precooling gas turbine inlet air with cold water supplied by an aquifer thermal energy storage system provided lower cost electricity than simply increasing the size of the turbine for meteorological and geological conditions existing in the Minneapolis vicinity. A 15 to 20 percent cost reduction resulted for both 0.05 and 0.2 annual operating factors. In contrast, ice storage precooling was found to be between 5 and 20 percent more expensive than larger gas turbines for the Minneapolis location. In Birmingham, aquifer thermal energy storage precooling was preferred at the higher capacity factor and ice storage precooling was the best option at the lower capacity factor. In both cases, the levelized cost was reduced by approximately 5 percent when compared to larger gas turbines. DOE

N93-25157*# National Aeronautics and Space Administration, Washington, DC.
THE ATMOSPHERIC EFFECTS OF STRATOSPHERIC AIRCRAFT. REPORT OF THE 1992 MODELS AND MEASUREMENTS WORKSHOP. VOLUME 1: WORKSHOP OBJECTIVES AND SUMMARY
MICHAEL J. PRATHER, ed. and ELLIS E. REMSBURG, ed. (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) Mar. 1993 132 p Workshop held in Satellite Beach, FL, 3-7 Feb. 1992
(NASA-RP-1292-VOL-1; NAS 1.61:1292-VOL-1) Avail: CASI HC A07/MF A02

This Workshop on Stratospheric Models and Measurements (M&M) marks a significant expansion in the history of model intercomparisons. It provides a foundation for establishing the credibility of stratospheric models used in environmental assessments of chlorofluorocarbons, aircraft emissions, and climate-chemistry interactions. The core of the M&M comparisons involves the selection of observations of the current stratosphere (i.e., within the last 15 years): these data are believed to be accurate and representative of certain aspects of stratospheric chemistry and dynamics that the models should be able to simulate.
Author

N93-25158*# National Aeronautics and Space Administration, Washington, DC.
THE ATMOSPHERIC EFFECTS OF STRATOSPHERIC AIRCRAFT. REPORT OF THE 1992 MODELS AND MEASUREMENTS WORKSHOP. VOLUME 2: COMPARISONS WITH GLOBAL ATMOSPHERIC MEASUREMENTS
MICHAEL J. PRATHER, ed. and ELLIS E. REMSBERG, ed. (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) Mar. 1993 254 p Workshop held in Satellite Beach, FL, 3-7 Feb. 1992
(NASA-RP-1292-VOL-2; NAS 1.61:1292-VOL-2) Avail: CASI HC A12/MF A03

This Workshop on Stratospheric Models and Measurements (M&M) marks a significant expansion in the history of model intercomparisons. It provides a foundation for establishing the credibility of stratospheric models used in environmental assessments of chlorofluorocarbons, aircraft emissions, and climate-chemistry interactions. The core of the M&M comparisons involves the selection of observations of the current stratosphere (i.e., within the last 15 years): these data are believed to be accurate and representative of certain aspects of stratospheric chemistry and dynamics that the models should be able to simulate.
Author (revised)

N93-25159*# National Aeronautics and Space Administration, Washington, DC.
THE ATMOSPHERIC EFFECTS OF STRATOSPHERIC AIRCRAFT. REPORT OF THE 1992 MODELS AND MEASUREMENTS WORKSHOP. VOLUME 3: SPECIAL DIAGNOSTIC STUDIES
MICHAEL J. PRATHER, ed. and ELLIS E. REMSBERG, ed. (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) Mar. 1993 335 p Workshop held in Satellite, FL, 3-7 Feb. 1992
(NASA-RP-1292-VOL-3; NAS 1.61:1292-VOL-3) Avail: CASI HC A15/MF A03

This Workshop on Stratospheric Models and Measurements (M&M) marks a significant expansion in the history of model intercomparisons. It provides a foundation for establishing the credibility of stratospheric models used in environmental assessments of chlorofluorocarbons, aircraft emissions, and climate-chemistry interactions. The core of the M&M comparisons involves the selection of observations of the current stratosphere (i.e., within the last 15 years): these data are believed to be accurate and representative of certain aspects of stratospheric chemistry and dynamics that the models should be able to simulate.
Author

N93-25645# Massachusetts Inst. of Tech., Lexington.
SETTING VALUES FOR TDWR/LLWAS 3 INTEGRATION PARAMETERS
RODNEY E. COLE and RUSSELL F. TODD 5 Feb. 1993 21 p
(Contract DTFA01-89-Z-02033; F19628-90-C-0002)
(AD-A260740; DOT/FAA/NR-92/12) Avail: CASI HC A03/MF A01

In 1993 the FAA will begin deploying the Terminal Doppler Weather Radar (TDWR) at selected airports in the United States. Forty-five TDWRs will be collocated with LLWAS 3 systems, and the FAA has decided that all TDWRs collocated with LLWAS 3 systems must be integrated with LLWAS 3 prior to commissioning. The algorithm chosen to perform this integration must be supplied with a set of site-specific parameters. This report gives guidance on how to set the values of theme integration parameters. DTIC

N93-25837# Mitre Corp., McLean, VA. Program Office.
SMALL SATELLITES AND RPA'S IN GLOBAL-CHANGE RESEARCH
P. BANKS, J. CORNWALL, F. DYSON, N. FORTSON, and R. GARWIN 1 Dec. 1992 207 p
(AD-A260762; JSR-91-330) Avail: CASI HC A10/MF A03

This report contains an investigation of those global change science problems that can be addressed by remotely piloted aircraft or by small satellites, including the relationship to the NASA EOS program. New types of measurements that could be made possible by such satellite or aircraft platforms are pointed out. Issues of technical feasibility and cost are examined, as well as the role of new technology developed through DOD and other programs. Possible joint DOD/Global Science satellite missions are also discussed. DTIC

N93-25874# Nevada Univ. System, Reno. Atmospheric Sciences Center.
NATURAL AND AUGMENTED SNOWFALL GROWTH PROCESSES AND THEIR INTERACTIONS WITH THE NATURAL AND MODIFIED AEROSOL Final Report, 1 Mar. 1989 - 30 Apr. 1990
J. WARBURTON Jul. 1991 57 p
(Contract NA89RA-H-09087)
(PB93-153096) Avail: CASI HC A04/MF A01

The second annual report describes the activities performed under seven separate tasks. These tasks dealt with the development of a trace chemical method of assessing the effects of seeding in a snow producing environment and the use of the stable isotopes of water for assessing the regions of ice-phase water capture in the cloud systems from which precipitation fell in the study regions. They also dealt with the theoretical aspects of these trace chemical programs of study and with the roles which trace impurities can play in affecting the growth characteristics of ice particles in supercooled clouds and of the shapes and number fluxes of ice crystals which occur under both natural and artificially seeded conditions. These tasks also included studies of the supercooled liquid water and ice contents of winter storms over the central Sierra Nevada, both spatially and temporally through the use of ground-based remote sensing radar and microwave radiometers. Some work was also conducted on the further development of new aircraft instrumentation for measuring atmospheric motions and the microphysical composition of winter orographic clouds. Author (DTIC)

N93-26243# Sorbent Technologies Corp., Twinsburg, OH.
DEVELOPMENT AND DEMONSTRATION OF A NEW FILTER SYSTEM TO CONTROL EMISSIONS DURING JET ENGINE TESTING Final Report, Feb. 1990 - Sep. 1992
B. W. NELSON, D. A. VANSTONE, and S. G. NELSON 15 Oct. 1992 79 p
(Contract F08635-90-C-0053)
(AD-A261203; CEL-TR-92-49) Avail: CASI HC A05/MF A01

Measurable quantities of NO(x), CO and small particulates are produced and are emitted into the atmosphere during the testing of aircraft engines in jet engine test cells (JETC's). These emissions have been and are a concern to the Air Force and to others who test aircraft engines. The large quantities of exhaust gases that are generated, the wide range of testing conditions that are normally employed, and the sensitivity of engines to back pressures make control difficult and the use of conventional control technologies impractical. A need exists for a simple, low-cost method to control the emissions. In a Phase 1 SBIR project, Sorbent Technologies Corporation (Sorbtech) explored the ability of vermiculite to reduce or capture contaminants in exhaust gas streams. During the Phase 2 SBIR project described in this report, Sorbtech investigated how vermiculite might be employed in a commercial system to control emissions from JETC's and how chemical additions to vermiculite might enhance its NO(x)-removal abilities. The objectives of the Phase 11 project were to develop and to demonstrate a suitable filter design involving vermiculite that will control NO(x), CO, and small-particulate emissions during jet-engine testing. DTIC

N93-26327# RAND Corp., Santa Monica, CA.
AEROSPACE-PLANE FLIGHTS AND STRATOSPHERIC OZONE: REVIEW AND PRELIMINARY ASSESSMENT OF THE NATIONAL AEROSPACE PLANE (NASP) OPERATIONS
S. K. LIU 1992 63 p
(Contract F49620-91-C-0003)
(RAND/N-3464-AF) Avail: CASI HC A04/MF A01

The United States is now engaged in a major National Aerospace Plane (NASP) effort keyed to the goal of achieving low earth orbit using an air-breathing single-stage-to-orbit (SSTO) vehicle, the X-30. This goal requires meeting many sensitive technology and integration challenges. The NASP program management office fully recognizes these challenges and has mounted numerous concerted projects to achieve the required technology advances, in many instances accelerating progress *substantially in fields several decades old. RAND undertook a* study under sponsorship of Air Force's Directorate of Program Planning and Integration (SAF/AQX) to provide an integrated overview of the benefits, cost, and technical risks of potential NASP-derived vehicles (NDV). One task of this larger study was to examine some of the critical environmental aspects of the NASP program, specifically the effect of operational NDV's on stratospheric ozone and on noise intensity from sonic booms. The stratospheric ozone research and first-order estimates of the possible perturbation of water vapor and NOx content induced by the operation of the National Aerospace Plane (NASP) is reviewed. The primary purpose of this analysis is to assess the effect on stratospheric ozone from an operational fleet of NDV's.
Author (revised)

N93-26529# Little (Arthur D.), Inc., Cambridge, MA.
IMPROVED SELECTIVE CATALYTIC NOX CONTROL TECHNOLOGY FOR COMPRESSOR STATION RECIPROCATING ENGINES Final Report, Sep. 1991 - Sep. 1992
C. E. BENSON, K. R. BENEDEK, and P. J. LOFTUS Sep. 1992 89 p See also PB86-110186
(Contract GRI-5091-254-2235)
(PB93-158566; GRI-92/0364) Avail: CASI HC A05/MF A01

The objective of the program was to identify and assess improvements to Selective Catalytic Reduction (SCR) exhaust gas NO(x) control processes for stationary reciprocating engines at pipeline compressor stations. Based on commercial application experience in Europe and the U.S., it is evident that SCR systems have been successfully applied to control NO(x) emissions from natural gas fueled stationary engines. Nevertheless, cost, maintenance, and automation related aspects of most commercial SCR systems currently render the technology an unattractive NO(x) control option for pipeline compressor station engines. Desirable and feasible improvements to SCR technology were defined through interaction with technology consumers (pipeline companies) and technology suppliers (SCR manufacturers), followed by independent analyses. The key technologies recommended for advancement include: a non-extractive, continuous emissions monitoring system, integration and automation of optimized engine/SCR systems, engine NOx

emission mapping and feed-forward control of the SCR process, and qualification and use of commercially available low phosphorus lubricating oils. NTIS

N93-26533# Pennsylvania State Univ., University Park. Propulsion Engineering Research Center.
OXIDES OF NITROGEN EMISSIONS FROM TURBULENT HYDROCARBON/AIR JET DIFFUSION FLAMES, PHASE 2 Final Report, Jan. 1990 - Aug. 1992
S. R. TURNS and R. V. BANDARU Sep. 1992 111 p See also PB91-184952
(Contract GRI-5086-260-1308)
(PB93-152478; PSU-ME-R-90/91-0005-PHASE-2; GRI-92/0470-PHASE-2) Avail: CASI HC A06/MF A02

Measurements of oxides of nitrogen and carbon monoxide emission indices, flame radiant fractions, and visual flame dimensions were made for turbulent jet diffusion flames covering a wide range of test conditions. Parameters investigated included: initial jet velocity, jet diameter, fuel type, fuel dilution with inerts, partial premixing with air, and location and quantity of radial air injection. Detailed temperature measurements were also obtained for selected test conditions. The objectives of the study were (1) to develop a well-characterized data base to guide modeling efforts, and (2) to understand the relationships among NO(x) and CO emissions and flow conditions, fuel variables, and flame radiation. A major finding of the study was that the effects on NO(x) of residence time, flame temperature, and departure of the radical pool from equilibrium, whether caused by variations in initial jet velocity, jet diameter, fuel type, fuel dilution, or partial premixing, were well-characterized using two parameters: a characteristic nonadiabatic flame temperature, and a global residence time. Additional fuel-type dependencies, relating to the relative importance of prompt NO, were also found. NTIS

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A93-33793
CONTROLLER DESIGN USING FUZZY LOGIC - A CASE STUDY
KARL H. KIENITZ (Inst. Tecnologico de Aeronautica, Sao Jose dos Campos, Brazil) Automatica (ISSN 0005-1098) vol. 29, no. 2 March 1993 p. 549-554. refs
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Controller design is considered for system specifications which are not handled naturally by analytical methods. Using fuzzy sets and related theory, system specifications are translated into preference functions which are readily combined with search methods to determine adequate controller parameters. This contribution integrates the discussion of the theory and its step-by-step application to aircraft control during the flare-out phase of landing. Author

A93-33878#
PREDICTION OF HELICOPTER COMPONENT LOADS USING NEURAL NETWORKS
DAVID J. HAAS, JOEL MILANO, and LANCE FLITTER (U.S. Navy, David Taylor Model Basin, Bethesda, MD) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 12-25. refs
(AIAA PAPER 93-1301)

An artificial neural network is trained using helicopter flight test data to predict rotor system component loads during high-speed maneuvering flight. Inputs to the network include control positions and aircraft state parameters. These parameters can be easily measured in the nonrotating system, i.e., the fuselage, and vary at a relatively low-frequency. A network design sensitivity study is conducted and several networks are developed for three loads; the rotor blade pushrod load, blade normal bending moment, and main-rotor damper load. Prediction accuracy is evaluated using a validation data set consisting of symmetric pull out maneuvers, rolling pull out maneuvers, and climbing turns not contained in the training data set. A traditional statistical approach, stepwise multiple linear regression, is also utilized and the two methods are compared and contrasted. Correlation coefficients from 84 percent to 97 percent are achievable using the neural network model for all three loads. Through a unified approach involving both neural network and statistical analysis greater accuracy and understanding of the neural network is attained. Author

A93-33883*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NEW PARALLEL-VECTOR FINITE ELEMENT ANALYSIS SOFTWARE ON DISTRIBUTED-MEMORY COMPUTERS
JIANGNING QIN and DUC T. NGUYEN (Old Dominion Univ., Norfolk, VA) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 1 Washington American Institute of Aeronautics and Astronautics 1993 p. 98-102. refs
(Contract NAG1-858)
(AIAA PAPER 93-1307) Copyright

A new parallel-vector finite element analysis software package MPFEA (Massively Parallel-vector Finite Element Analysis) is developed for large-scale structural analysis on massively parallel computers with distributed-memory. MPFEA is designed for parallel generation and assembly of the global finite element stiffness matrices as well as parallel solution of the simultaneous linear equations, since these are often the major time-consuming parts of a finite element analysis. Block-skyline storage scheme along with vector-unrolling techniques are used to enhance the vector performance. Communications among processors are carried out concurrently with arithmetic operations to reduce the total execution time. Numerical results on the Intel iPSC/860 computers (such as the Intel Gamma with 128 processors and the Intel Touchstone Delta with 512 processors) are presented, including an aircraft structure and some very large truss structures, to demonstrate the efficiency and accuracy of MPFEA. Author

A93-33973#
ON THE ORDER REDUCTION OF LQG DESIGNED CONTROLLERS
E. NISSIM (Technion - Israel Inst. of Technology, Haifa) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1993 p. 1000-1009. refs
(AIAA PAPER 93-1420) Copyright

LQG procedures for controller design yield compensators of the same order of the plant. However, practical design considerations often dictate low order controllers. This paper presents a procedure which allows the reduction of these high order LQG designed controllers to low order ones. The proposed controller reduction method is based on the same performance index J used while designing the optimal regulator. The proposed method ensures that the value of J for the system with the reduced order controller is essentially identical to the value obtained with the full order controller. Numerical results are presented which illustrate the effectiveness of the method. Author

A93-34219#
INTEGRATED STRUCTURAL TAILORING AND ADAPTIVE CONTROL OF ADVANCED FLIGHT VEHICLE STRUCTURAL VIBRATION
L. LIBRESCU, L. MEIROVITCH, and O. SONG (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In* AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 34th and AIAA/ASME Adaptive Structures Forum, La Jolla, CA, Apr. 19-22, 1993, Technical Papers. Pt. 6 Washington American Institute of Aeronautics and Astronautics 1993 p. 3457-3465. refs
(Contract AF-AFOSR-91-0351)
(AIAA PAPER 93-1697) Copyright

This paper presents an integrated approach combining structural tailoring with the converse piezoelectric effect for the purpose of actively controlling the vibration characteristics of advanced flight vehicle structures. The structural model consists of a thin/thick-walled closed cross-section cantilevered beam whose constituent layers exhibit elastic anisotropic properties. In addition, a system of piezoelectric actuators bonded to or embedded into the structure generates a localized strain field in response to an injected electric current, thus producing a change in the dynamic characteristics of the structure. Results reveal that the integration of both techniques can play a major role in enhancing the dynamic characteristics of aircraft wings, and in particular in controlling vibration and preventing flutter instability. Author

A93-34264* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ATMOSPHERIC TURBULENCE SIMULATION FOR ROTORCRAFT APPLICATIONS
J. RIAZ, J. V. R. PRASAD, D. P. SCHRAGE (Georgia Inst. of Technology, Atlanta), and G. H. GAONKAR (Florida Atlantic Univ., Boca Raton) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38. no. 1 Jan. 1993 p. 84-88. AHS, Annual Forum, 47th, Phoenix, AZ, May 6-8, 1991, Proceedings. Vol. 1, p. 579-584. Previously cited in issue 03, p. 447, Accession no. A92-14368 refs
(Contract NCA2-512)
Copyright

A93-34536* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPTIMAL DISCRETE-TIME DYNAMIC OUTPUT-FEEDBACK DESIGN - A W-DOMAIN APPROACH
CHEOLKEUN HA, UY-LOI LY, and MARTIN C. BERG (Washington Univ., Seattle) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 3 May-June 1993 p. 534-540. AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3, p. 1769-1781. Previously cited in issue 21, p. 3735, Accession no. A91-49754 refs
(Contract NAG1-1210)
Copyright

A93-34539* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPTIMAL OPEN MULTISTEP DISCRETIZATION FORMULAS FOR REAL-TIME SIMULATION
DANIEL D. MOERDER (NASA, Langley Research Center, Hampton, VA), ANTHONY J. CALISE, and PAUL CLEMMONS (Georgia Inst. of Technology, Atlanta) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 3 May-June 1993 p. 557-563. refs
Copyright

The performance of digital real-time simulations is considered. A figure of merit is derived that quantifies a simulation's fidelity in terms of the time-domain discrepancy between its output and that of the plant it simulates, assuming that the plant is linearizable and asymptotically stable. This performance index is then used in deriving an easily automated procedure for calculating optimal values for free parameters in plant discretizations based on a generalized form of open linear multistep integration formulas. The theory is demonstrated in simulating the rigid-body dynamics of a fully articulated helicopter rotor blade system. Author

A93-35307
AN ALGORITHM WITH PREDICTION IN A CONTROL PROBLEM WITH FUNCTIONAL CONSTRAINTS [ALGORITM S PROGNOZIROVANIEM V ZADACHE UPRAVLENIIA S FUNKTSIONAL'NYMI OGRANICHENIIAMI]
A. N. AKIMOV, V. N. BUKOV, and A. A. MISHCHENKO (Voenno-Vozdushnaia Inzhenernaia Akademiia, Moscow, Russia) Avtomatika i Telemekhanika (ISSN 0005-2310) no. 3 March 1993 p. 63-70. In Russian. refs
Copyright

The problem of retaining constraints on the state of a dynamic plant is extended to the case where the constraint conditions are specified in terms of functional relations. A control algorithm with a prediction model is developed which ensures that the dynamic plant remains within the stability region. The practical application of the algorithm is illustrated by an example involving an automatic limiter of the angle of attack of an aircraft which ensures the stability of its lateral motion. AIAA

A93-35637
EXPERIMENTAL INVESTIGATIONS OF ASYMMETRIC VORTEX FLOWS BEHIND ELLIPTIC CONES AT INCIDENCE
WOLFGANG H. STAHL (King Fahad Univ. of Petroleum and Minerals, Dhahran, Saudi Arabia) AIAA Journal (ISSN 0001-1452) vol. 31, no. 5 May 1993 p. 966-968. Research supported by DLR and King Fahad Univ. of Petroleum and Minerals refs
Copyright

A dye flow visualization technique was used to study three elliptic cones of thickness ratios (tau) 1.0, 0.65, and 0.40, respectively, and a sharp-edged delta wing with tau varying between 0.09 and 0.18 along the chord, in a water tunnel at high incidence. Results show that the degree of asymmetry of the vortex flows behind the cones decrease as the cones become flatter, i.e., with tau decreasing from 1 to 0.4 and tau equals zero for the delta wing. AIAA

A93-35663
A DESIGN CONCEPT FOR A FLIGHT VEHICLE COMPUTER SYSTEM WITH ARTIFICIAL INTELLIGENCE ELEMENTS [KONTSEPTSIIA POSTROENIIA VYCHISLITEL'NOGO KOMPLEKSA LETATEL'NOGO APPARATA S ELEMENTAMI ISKUSSTVENNOGO INTELLEKTA]
V. D. TIURIN and S. IU. GUSNIN *In* Structure of onboard computing systems with artificial-intelligence elements Moscow Izdatel'stvo Moskovskogo Aviatsionnogo Instituta 1991 p. 4-10. In Russian. refs
Copyright

A design concept for an onboard computer system with elements of artificial intelligence is presented which is based on the idea of modular asynchronous evolving systems. The components of the computer system represent a hierarchical architecture containing at least five levels that correspond to generalized functional tasks. These include tools for the communication between the onboard computer system and the environment (sensory level), tools for the organization of the operation of control loops that solve individual functional tasks (motor level), tools coordinating the operation of control circuits, operation control tools, and means of accumulating data on the life cycle of the flight vehicle. AIAA

N93-25073*# Computer Sciences Corp., Hampton, VA.
A COMPARISON USING APPL AND PVM FOR A PARALLEL IMPLEMENTATION OF AN UNSTRUCTURED GRID GENERATION PROGRAM
TREY ARTHUR and MICHAEL J. BOCKELIE Jan. 1993 16 p
(Contract NAS1-19038; RTOP 505-90-53-02)
(NASA-CR-191425; NAS 1.26:191425; TAO-60322) Avail: CASI HC A03/MF A01

Efforts to parallelize the VGRIDSG unstructured surface grid generation program are described. The inherent parallel nature of the grid generation algorithm used in VGRIDSG was exploited on a cluster of Silicon Graphics IRIS 4D workstations using the message passing libraries Application Portable Parallel Library (APPL) and Parallel Virtual Machine (PVM). Comparisons of speed up are presented for generating the surface grid of a unit cube and a Mach 3.0 High Speed Civil Transport. It was concluded that for this application, both APPL and PVM give approximately the same performance, however, APPL is easier to use.
Author (revised)

N93-25084*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
CURRENT RESEARCH ACTIVITIES: APPLIED AND NUMERICAL MATHEMATICS, FLUID MECHANICS, EXPERIMENTS IN TRANSITION AND TURBULENCE AND AERODYNAMICS, AND COMPUTER SCIENCE Semiannual Final Report, 1 Apr. - 30 Sep. 1992
Washington Dec. 1992 93 p Sponsored by NASA. Langley Research Center
(Contract NAS1-18605; NAS1-19480; RTOP 505-90-52-01)
(NASA-CR-191408; NAS 1.26:191408) Avail: CASI HC A05/MF A01

Research conducted at the Institute for Computer Applications in Science and Engineering in applied mathematics, numerical analysis, fluid mechanics including fluid dynamics, acoustics, and combustion, aerodynamics, and computer science during the period 1 Apr. 1992 - 30 Sep. 1992 is summarized. Author (revised)

N93-25130*# California Univ., Berkeley. Computer Science Div.
ROBO-LINE STORAGE: LOW LATENCY, HIGH CAPACITY STORAGE SYSTEMS OVER GEOGRAPHICALLY DISTRIBUTED NETWORKS
RANDY H. KATZ, THOMAS E. ANDERSON, JOHN K. OUSTERHOUT, and DAVID A. PATTERSON Sep. 1991 27 p
(Contract NAG2-591)
(NASA-CR-192910; NAS 1.26:192910; UCB/CSD-91/651) Avail: CASI HC A03/MF A01

Rapid advances in high performance computing are making possible more complete and accurate computer-based modeling of complex physical phenomena, such as weather front interactions, dynamics of chemical reactions, numerical aerodynamic analysis of airframes, and ocean-land-atmosphere interactions. Many of these 'grand challenge' applications are as demanding of the underlying storage system, in terms of their capacity and bandwidth requirements, as they are on the computational power of the processor. A global view of the Earth's ocean chlorophyll and land vegetation requires over 2 terabytes of raw satellite image data. In this paper, we describe our planned research program in high capacity, high bandwidth storage systems. The project has four overall goals. First, we will examine new methods for high capacity storage systems, made possible by low cost, small form factor magnetic and optical tape systems. Second, access to the storage system will be low latency and high bandwidth. To achieve this, we must interleave data transfer at all levels of the storage system, including devices, controllers, servers, and communications links. Latency will be reduced by extensive caching throughout the storage hierarchy. Third, we will provide effective management of a storage hierarchy, extending the techniques already developed for the Log Structured File System. Finally, we will construct a prototype high capacity file server, suitable for use on the National Research and Education Network (NREN). Such research must be a Cornerstone of any coherent program in high performance computing and communications. Author (revised)

N93-25410 Michigan Univ., Ann Arbor.
OPTIMAL THRUST MAGNITUDE ON A SINGULAR ARC IN ATMOSPHERIC FLIGHT Ph.D. Thesis
SUDHAKAR MEDEPALLI 1992 180 p
Avail: Univ. Microfilms Order No. DA9303785

In optimal control theory, the cases where the second order necessary conditions are trivially satisfied are named the singular cases and the corresponding controls, the singular controls. These are shown to occur quite frequently in a wide variety of practical applications and play an important role. Lie and Poisson brackets can be used to express these singular controls in a very elegant and systematic manner. However, in the literature, Lie bracket solutions are derived only for the simplest cases of a single or multiple inputs appearing linearly in the equations of motion. These come under a category called the totally singular arcs, where all the controls are singular simultaneously. The cases where both singular and non-singular cases occur together, however, are quite common in the literature, especially in trajectory optimization problems. These are called partially singular arcs. This dissertation extends the Lie and Poisson bracket solutions to partially singular arcs of order one. The significance of singular controls in trajectory optimization is illustrated through an example orbital plane change problem. A general trajectory optimization problem in the atmosphere is shown to be partially singular with the thrust magnitude being the singular control and the aerodynamic controls being non-singular. The extended Lie bracket solution is then applied to obtain the thrust magnitude expression on the singular arc. This is shown to be identical to the expression derived by conventional means. It is also shown to be computationally more efficient and to preserve any symmetry properties in the problem. Some interesting sub-cases are studied with the help of the general expression. Further extensions of the Lie bracket solution are suggested for constrained arcs and higher order singular arcs. Vector formulation is used throughout the thesis to make the results concise and independent of the choice of the coordinate system. An example canonical transformation to flight path variables is derived to illustrate how all the results in vector form can be translated in terms of any desired set of variables.
Dissert. Abstr.

N93-25600*# Sterling Software, Moffett Field, CA.
SCIENTIFIC VISUALIZATION USING THE FLOW ANALYSIS SOFTWARE TOOLKIT (FAST)
GORDON V. BANCROFT, PAUL G. KELAITA, R. KEVIN MCCABE, FERGUS J. MERRITT, TODD C. PLESSEL, TIMOTHY A. SANDSTROM, and JOHN T. WEST *In* NASA, Washington, Technology 2002: The Third National Technology Transfer Conference and Exposition, Volume 1 p 366-375 Feb. 1993
Avail: CASI HC A02/MF A04

Over the past few years the Flow Analysis Software Toolkit (FAST) has matured into a useful tool for visualizing and analyzing scientific data on high-performance graphics workstations. Originally designed for visualizing the results of fluid dynamics research, FAST has demonstrated its flexibility by being used in several other areas of scientific research. These research areas include earth and space sciences, acid rain and ozone modelling, and automotive design, just to name a few. This paper describes the current status of FAST, including the basic concepts, architecture, existing functionality and features, and some of the known applications for which FAST is being used. A few of the applications, by both NASA and non-NASA agencies, are outlined in more detail. Described in the Outlines are the goals of each visualization project, the techniques or 'tricks' used lo produce the desired results, and custom modifications to FAST, if any, done to further enhance the analysis. Some of the future directions for FAST are also described. Author

N93-25611*# Johns Hopkins Univ., Laurel, MD. Applied Physics Lab.
CONTROL OF COMPLEX DYNAMIC SYSTEMS BY NEURAL NETWORKS
JAMES C. SPALL and JOHN A. CRISTION *In* NASA, Washington, *Technology 2002: The Third National Technology Transfer* Conference and Exposition, Volume 1 p 473-482 Feb. 1993
(Contract N00039-91-C-0001)
Avail: CASI HC A02/MF A04

This paper considers the use of neural networks (NN's) in controlling a nonlinear, stochastic system with unknown process equations. The NN is used to model the resulting unknown control law. The approach here is based on using the output error of the

system to train the NN controller without the need to construct a separate model (NN or other type) for the unknown process dynamics. To implement such a direct adaptive control approach, it is required that connection weights in the NN be estimated while the system is being controlled. As a result of the feedback of the unknown process dynamics, however, it is not possible to determine the gradient of the loss function for use in standard (back-propagation-type) weight estimation algorithms. Therefore, this paper considers the use of a new stochastic approximation algorithm for this weight estimation, which is based on a 'simultaneous perturbation' gradient approximation that only requires the system output error. It is shown that this algorithm can greatly enhance the efficiency over more standard stochastic approximation algorithms based on finite-difference gradient approximations. Author

N93-25969*# College of William and Mary, Williamsburg, VA. Dept. of Computer Science.
THE USE OF MULTIPLE MODELS IN CASE-BASED DIAGNOSIS
STAMOS T. KARAMOUZIS and STEFAN FEYOCK *In* NASA. Goddard Space Flight Center, The 1993 Goddard Conference on Space Applicati ons of Artificial Intelligence p 83-90 1993
(Contract NCC1-159)
Avail: CASI HC A02/MF A03

The work described in this paper has as its goal the integration of a number of reasoning techniques into a unified intelligent information system that will aid flight crews with malfunction diagnosis and prognostication. One of these approaches involves using the extensive archive of information contained in aircraft accident reports along with various models of the aircraft as the basis for case-based reasoning about malfunctions. Case-based reasoning draws conclusions on the basis of similarities between the present situation and prior experience. We maintain that the ability of a CBR program to reason about physical systems is significantly enhanced by the addition to the CBR program of various models. This paper describes the diagnostic concepts implemented in a prototypical case based reasoner that operates in the domain of in-flight fault diagnosis, the various models used in conjunction with the reasoner's CBR component, and results from a preliminary evaluation. Author

N93-26294# Naval Postgraduate School, Monterey, CA.
CONSIDERATIONS FOR SPACE AND NAVAL AVIATION APPLICATIONS OF FERROELECTRIC MEMORY M.S. Thesis
THEODORE A. VETTER Dec. 1992 77 p
(AD-A261300) Avail: CASI HC A05/MF A01

The purpose of this thesis is to introduce the reader to Ferroelectric memory and discuss considerations for possible space and Naval aviation applications. Ferroelectric memory's characteristics and basic mechanism are discussed. A broad spectrum of existing computer memory types are presented for comparison. The memory requirements of Space Shuttle, Landsat, Intelsat VI and Hubble Space Telescope as well as the Navy E-2 Hawkeye and EA-6B Prowler aircraft are given as possible examples of space and Naval aviation applications of ferroelectric memory. DTIC

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A93-33710
THE ANALYSIS OF VISCOUS WAKES NOISE IN AXIAL FLOW COMPRESSOR
WENLONG YU and PING FANG (Xian Jiaotong Univ., China) Acta Aerodynamica Sinica (ISSN 0258-1825) vol. 10, no. 4 Dec. 1992 p. 482-487. In Chinese. refs

This paper studies the fluctuating lift of a cambered airfoil under sinusoidal gusts. The equations of the fluctuating lift are then derived. The effects of cascade geometry parameters and aerodynamic parameters of the rotor cascade and the stator cascade in the axial flow compressor on the rotor fluctuating lift and noise level are analyzed. Author (revised)

A93-34957* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRELIMINARY EXPERIMENTS ON ACTIVE CONTROL OF FAN NOISE FROM A TURBOFAN ENGINE
R. H. THOMAS, R. A. BURDISSO, C. R. FULLER, and W. F. O'BRIEN (Virginia Polytechnic Inst. and State Univ., Blacksburg) Journal of Sound and Vibration (ISSN 0022-460X) vol. 161, no. 3 March 8, 1993 p. 532-537. refs
(Contract NAS1-18471)
Copyright

In the preliminary experiments reported here, active acoustic sources positioned around the circumference of a turbofan engine were used to control the fan noise radiated forward through the inlet. The main objective was to demonstrate the potential of active techniques to alleviate the noise pollution that will be produced by the next generation of larger engines. A reduction of up to 19 dB in the radiation directivity was demonstrated in a zone that encompasses a 30-deg angle, near the error sensor, while spillover effects were observed toward the lateral direction. The simultaneous control of two tones was also demonstrated using two identical controllers in a parallel control configuration. AIAA

N93-25649# Aeronautical Research Labs., Melbourne (Australia).
IN-FLIGHT EVALUATION OF NOISE LEVELS AND ASSESSMENT OF ACTIVE NOISE REDUCTION SYSTEMS IN THE SEAHAWK S-70B-2 HELICOPTER
R. B. KING and D. A. FORAN 1992 46 p
(AD-A260689; ARL-TR-9; DODA-AR-007-077) Avail: CASI HC A03/MF A01

Cabin and at-ear sound spectra in the S-70B-2 at various crew positions and flight conditions were measured in order to determine the noise attenuation properties of the ALPHA helmet and the effectiveness of active noise reduction (ANR) systems developed by the Defence Research Agency-Aerospace Division (formerly the Royal Aerospace Establishment) and the BOSE Corporation. Results show that if newly proposed hearing conservation guidelines are adopted, aircrew wearing the ALPHA helmet would require additional attenuation devices. It is recommended that an ANR system be incorporated into the S-70B-2 as such a system would allow realistic flight duration to be maintained, improve voice communication, and reduce aircrew fatigue. DTIC

N93-25651# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.
FAR FIELD ROTOR NOISE Final Report
VALANA L. WELLS 22 Jan. 1993 27 p
(Contract DAAL03-90-G-0221)
(AD-A260703; ARO-28002.1-EG) Avail: CASI HC A03/MF A01

The work covered two main areas of research--the aerodynamics of rotor blades including viscous and high angle of attack effects and, secondly, the propagation of noise from the rotor blade, particularly the nonlinear propagation. The aerodynamics work included the development and testing of a Navier-Stokes computational solver for rotor blades which incorporates rotating, translating, flapping and feathering motions. Results, which focus on the British Experimental Rotor Programme (BERP) blade, clearly show the importance of including all motions in the calculation of aerodynamic-forces. The acoustics research concentrates on the development of a method for computing the nonlinear propagation of acoustic signals in the atmosphere. The method is based on a boundary-element discretization of the

time-dependent, nonlinear wave equation. Results, computed for a spherically symmetric domain, show an equivalence with Whitham's method up to the formation of a shock. DTIC

N93-25915# Southeastern Center for Electrical Engineering Education, Inc., Saint Cloud, FL.
DESIGN, FABRICATION, AND TESTING OF A THREE-DIMENSIONAL ACOUSTIC ORIENTATION INSTRUMENT (3-D AOI): DRAWINGS, ENGINEERING AND ASSOCIATED LISTS (CONCEPTUAL AND DEVELOPMENT DESIGN) Final Report, 1 May 1989 - 15 Apr. 1991
DAN D. FULGHAM and JEFFREY GABELMANN Dec. 1992 133 p
(Contract F33615-87-D-0609)
(AD-A260934; SWRI-PN-12-3384; AL-TR-1992-0154) Avail: CASI HC A07/MF A02

Subcontractor (Southwest Research Institute) provides a description of the hardware assembled and software created to develop the 3-D AOI. A Macintosh 2x computer is the heart of the system acting as a general controller and processor of data flowing from the Flight Information Package to the Audio Localization Cue Synthesizer, audio mixer, headphones, and data recording equipment. A National Instruments NB-DSP2300 digital signal processing board and NB-A2100 audio 1/0 board generate the audio signals, and National instruments LabView software is used to control the auditory display. The majority of this report is a description of the 18 LabView software modules created to control the 3-D AOI display. DTIC

N93-26343# Brown Univ., Providence, RI.. Div. of Engineering.
RESEARCH SUPPORT FOR THE LABORATORY FOR LIGHTWAVE TECHNOLOGY Final Report, 1 Jan. 1990 - 31 Dec. 1992
T. F. MORSE 31 Dec. 1992 101 p
(Contract AF-AFOSR-0062-90)
(AD-A261488; AFOSR-93-0102TR) Avail: CASI HC A06/MF A02

The Laboratory for Lightwave Technology at Brown University is one of the few university laboratories at which it is possible to design, fabricate, and characterize optical fibers of not only traditional, but of unusual design. These fibers have an increasingly important role in a host of applications of significance to the defense requirements of the United States. Among these are the following: fiber lasers for the measurement of clear air turbulence (in an important eye-safe region of the spectrum); and fiber sensors for the measurement of temperature and strain, not only in high temperature composite materials, but in structural concrete, which is important for roads, runways, and buildings. We are also engaged in research, an outgrowth of our work in optical fibers, on novel techniques for the formation of nanophase oxide particles, both ceramic and amorphous. The work on amorphous oxides is associated with our MCVD and OVD laboratories. In these labs, we have proposed and studied a new technique for the formation of multi-component oxides to be used in the doping of optical fiber preforms. In this synthesis, an aerosol of organometallic precursors is convectively transported into a reaction zone where it is pyrolized. The liquid aerosol is homogeneous at the molecular level, so that subsequent reactions produce glasses that are not phase separated. This has also been used to study the synthesis of high temperature ceramic nanophase single crystal oxides that may be produced at a high rate. The synthesis of both glasses and ceramics using novel techniques has meshed with our research in novel optical fibers and fiber sensors. In this report, we discuss the general activities of our laboratory. DTIC

N93-26551*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A LARGE HEMI-ANECHOIC ENCLOSURE FOR COMMUNITY-COMPATIBLE AEROACOUSTIC TESTING OF AIRCRAFT PROPULSION SYSTEMS
BETH A. COOPER Apr. 1993 15 p Presented at Noise-Con'93, Williamsburg, VA, 2-5 May 1993; sponsored by Noise-Con
(Contract RTOP 537-02-22)
(NASA-TM-106015; E-7572-1; NAS 1.15:106015) Avail: CASI HC A03/MF A01

A large hemianechoic (absorptive walls and acoustically hard floor) noise control enclosure was erected around a complex of test stands at the NASA Lewis Research Center in Cleveland, Ohio. This new state-of-the art Aeroacoustic Propulsion Laboratory (APL) provides an all-weather, semi secure test environment while limiting noise to acceptable levels in surrounding residential neighborhoods. The 39.6-m- (130-ft-) diameter geodesic dome houses the new nozzle aeroacoustic test rig (NATR), an ejector-powered Mach 0.3 free jet facility for acoustic testing of supersonic aircraft exhaust nozzles and turbomachinery. A multiaxis, force-measuring, powered lift facility (PLF) stand for testing short takeoff vertical-landing (STOVL) vehicles is also located in the dome. The design of the Aeroacoustic Propulsion Laboratory efficiently accommodates the research functions of two separate test rigs, one of which (NATR) requires a specialized environment for taking acoustic measurements. An absorptive fiberglass wedge treatment on the interior surface of the dome provides a hemianechoic environment for obtaining the accurate acoustic measurements required to meet research program goals. The APL is the first known geodesic dome structure to incorporate transmission-loss properties as well as interior absorption in a free-standing, community-compatible, hemianechoic test facility. Author

N93-26566# Wright Lab., Wright-Patterson AFB, OH.
OPTICALLY SMART SURFACES SURVIVABILITY TESTING AT MACH 3 Final Report
LINDA G. SMITH and GLENN W. WILLIAMS Jan. 1993 13 p
(AD-A261785; WL-TM-93-300) Avail: CASI HC A02/MF A01

Optically smart surfaces are being developed as wind tunnel diagnostic techniques for the Wright Laboratory. The optically smart surfaces are holographic optical elements constructed by flow coating an aluminum plate with photoresist as the emulsion material. Survivability of these optically smart surfaces was tested in the Mach 3 High Reynolds Number Facility. The surfaces did not survive at angle of attack to the freestream flow for higher Reynolds numbers and did survive when the surface was parallel to the freestream flow. DTIC

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A93-34821
AIRLINES, AIRPORTS AND ANTITRUST - A PROPOSED STRATEGY FOR ENHANCED COMPETITION
ROBERT M. HARDAWAY (George Washington Univ., Washington; Denver Univ., CO) and PAUL S. DEMPSEY (Denver Univ., CO) Journal of Air Law and Commerce (ISSN 0021-8642) vol. 58, no. 2 Winter 1992 p. 455-507. refs
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The present evaluation of the status of the U.S. airline industry at the end of 1992 notes that one or two dominant carriers control a virtually monopolistic percentage of terminal facilities at most large airports. The earning of oligopoly profits through airport monopolization, or essential fee-ownership of airport facilities, is not only seen to be anticompetitive, but also judged subject to antitrust action under section 2 of the Sherman Act. Antitrust strategies are discussed. AIAA

A93-34944
MANAGEMENT MISCUES, DELAYS SNARL C-17 PROGRAM

BRUCE A. SMITH Aviation Week & Space Technology (ISSN 0005-2175) vol. 138, no. 15 April 12, 1993 p. 30, 31.
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It has become apparent, 13 years after the inception of the C-17 military airlifter's development, that the various well-proven technologies which were to have been integrated in an essentially 'low risk' effort posed significant problems when encompassed by an aircraft of the C-17's size and intended operational versatility. In addition, performance capability requirements became more ambitious as the program progressed. An account is presently given of the program management, wing structure redesign and funding problems that have conspired to cause C-17 development delays and cost overruns. AIAA

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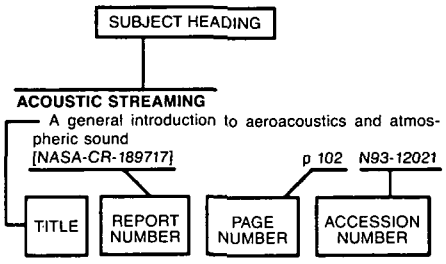
GENERAL

N93-25418# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. JAPAN. 30TH NATIONAL AEROSPACE LABORATORY CONFERENCE
9 Mar. 1993 54 p Transl. into ENGLISH of NAL (Tokyo, Japan), 20 Oct. 1992 p 1-42 Conference held in Tokyo, Japan, 20 Oct. 1992
(JPRS-JST-93-009) Avail: CASI HC A04/MF A01

Selected articles from the 30th National Aerospace Laboratory Conference held on 20 Oct. 1992 in Tokyo are included. Topics covered include: (1) ultrahigh bypass ratio engine; (2) research into supersonic intakes; (3) research into robust flight control system; (4) summary of research into liquid oxygen turbopumps; (5) microgravity fluid experiments; (6) research into antifriction bearings for use in space; (7) statistical distribution of compressive strength for smoothed testpiece of carbon/polyimide laminated material; and (8) experimental research into thermal/aerodynamic topics for hypersonic transport plane. CASI

Typical Subject Index Listing



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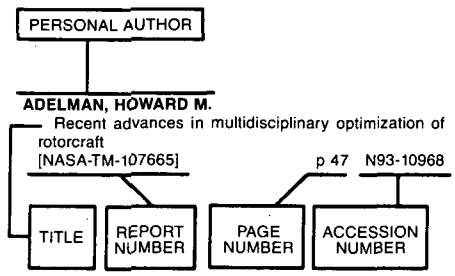

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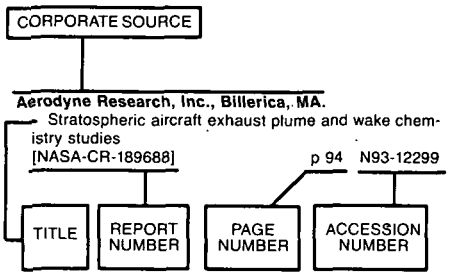

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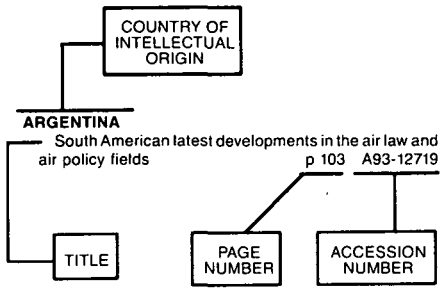

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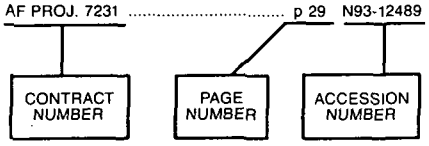

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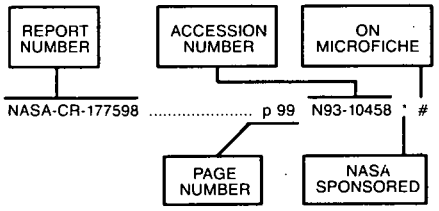

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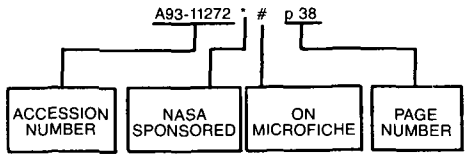

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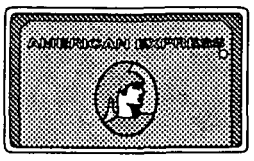

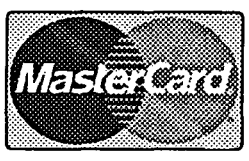

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